

**MAINE YANKEE**  
**321 Old Ferry Road, Wiscasset, Maine 04578**

February 6, 2017  
OMY-17-006  
10 CFR 50.71(e)(4)  
10 CFR 50.4(b)(6)

ATTN: Document Control Desk  
U.S Nuclear Regulatory Commission  
Washington, DC 20555-0001

72-30

Maine Yankee Atomic Power Company  
Maine Yankee Independent Spent Fuel Storage Installation  
NRC License No. DPR-36 (NRC Docket No. 50-309)

**Subject:** Biennial Update of the Maine Yankee License Termination Plan

Pursuant to the requirements of 10 CFR 50.71(e)(4) and 10 CFR 50.4(b)(6), Maine Yankee Atomic Power Company (Maine Yankee) is submitting a periodic update of the Maine Yankee License Termination Plan to the NRC. Enclosure 1 provides the pages changed in Revision 8 of the Maine Yankee License Termination Plan. Enclosure 2 provides Revision 9 of the Maine Yankee License Termination Plan in its entirety. These revisions were issued after Maine Yankee submitted its previous biennial update on February 5, 2015 (Reference 1).

The following table provides a summary of and the rationale for the changes implemented in Revisions 8 and 9 to the Maine Yankee License Termination Plan.

Revision	Summary of and Rationale for Changes Implemented
8	Chapter 7 was revised to update the Decommissioning Cost Estimate. It reflected the three-year update to the Decommissioning Funding Plan submitted to the NRC on December 16, 2015 (Reference 2).
9	Chapters 3, 7, and 8 were revised to update the Decommissioning Cost Estimate and schedule to reflect a new Decommissioning Cost Estimate and schedule that was submitted to the Federal Energy Regulatory Commission on September 30, 2016 and approved by FERC on November 16, 2016.

This letter contains no commitments. If you have any questions regarding this submittal, please contact Mr. J. Stanley Brown at (207) 882-1303.

I declare under penalty of perjury that the foregoing is true and correct. Executed on February 6, 2017.

Sincerely,



Wayne Norton  
Chief Nuclear Officer

NM5501  
NM5526

- References:
1. Maine Yankee letter to the NRC, "Biennial Update of the Maine Yankee License Termination Plan," dated February 5, 2015
  2. Maine Yankee letter to the NRC, "Three-Year Update to the Independent Spent Fuel Storage Installation Decommissioning Funding Plan," dated December 16, 2015

- Enclosures:
1. Revision 8 to Maine Yankee License Termination Plan (Change Pages Only)
  2. Revision 9 to Maine Yankee License Termination Plan

cc:

- Mr. Daniel Dorman, Administrator, USNRC Region 1 (Cover Letter Only)
- Mr. John Goshen P.E., Project Manager, USNRC NMSS (Cover Letter Only)
- Mr. R. Powell, Decommissioning Branch Chief, USNRC Region 1 (Cover Letter Only)
- Mr. P.J. Dostie, State of Maine (Cover Letter Only)
- Mr. J. Hyland, State of Maine (Cover Letter Only)
- Mr. Gerald C. Poulin, Chairman and President, Maine Yankee (Cover Letter Only)
- Mr. Joe Fay Esquire, General Counsel, Maine Yankee (Cover Letter Only)



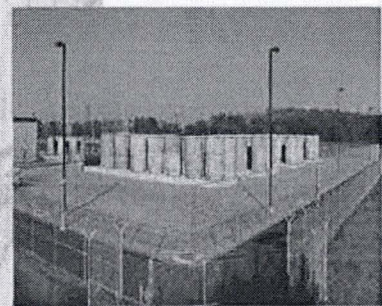
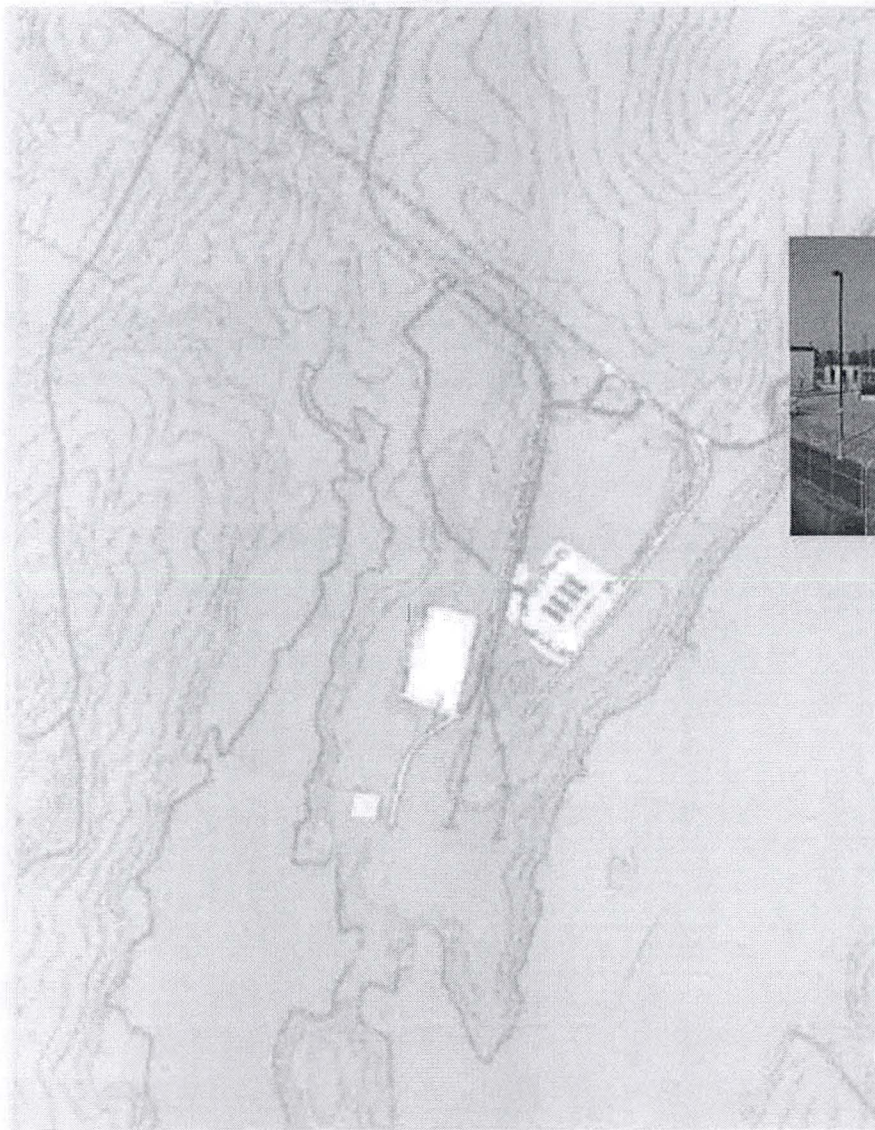
**ENCLOSURE 1 TO OMY-17-006**

**REVISION 8 TO MAINE YANKEE  
LICENSE TERMINATION PLAN  
(CHANGE PAGES ONLY)**

# License Termination Plan

Revision 8      January 2016

Submitted by:  
Maine Yankee Atomic Power Company



**Attachment 1 – Listing of Key Changes - License Termination Plan, Revision 8**

<b>Section</b>	<b>Proposed Change</b>	<b>Reason for Change</b>
<b>Chapter 7</b>	<b>Incorporate updated Decommissioning Cost Estimate</b>	<b>This change reflects the submittal of the three-year update to the Decommissioning Funding Plan to the NRC on December 16, 2015.</b>

## Attachment 2 – List of Effective Pages – License Termination Plan, Revision 8

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Attachment 3A	6	Figure 3-3-30 (Figures 3-1 through 3-29 Deleted)
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Attachment 6-11	3	
Attachment 6-12	3	
Attachment 6-13	4	
Attachment 6-14	3	
Attachment 6-15	3	
Attachment 6-16	3	Replaced by Attachment 2H
Attachment 6-17	4	Deleted
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**MAINE YANKEE**

**LTP SECTION 7**

**UPDATE OF SITE- SPECIFIC DECOMMISSIONING COSTS**

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## **7.0 UPDATE OF SITE- SPECIFIC DECOMMISSIONING COSTS**

### **7.1 Introduction**

In accordance with 10 CFR 50.82(a)(9)(ii)(F) and the guidance of Regulatory Guide 1.179, the site-specific cost estimates and funding plans are provided.

### **7.2 Decommissioning Cost Estimate**

The current Federal Energy Regulatory Commission (FERC) approved decommissioning cost estimate (Docket # ER13-1395-000) and cost estimate for management of spent fuel and GTCC waste is based on the Stipulation and Settlement Agreement between MYAPCO and the Connecticut Public Utilities Regulatory Authority, the Connecticut Office of Consumer Counsel, the Maine Public Utilities Commission, the Maine Office of Public Advocate, the Massachusetts Department of Public Utilities, and the Attorney General of Massachusetts dated April 30, 2013.

This cost estimate includes the cost associated with the projected ISFSI decommissioning costs and a funding assumption of 15 years of operations costs to manage spent fuel and GTCC waste. A funding mechanism provides that damage awards and settlement proceeds that MYAPCO receives in future phases of its litigation with the Department of Energy (DOE) will be applied to maintain the adequacy of the Nuclear Decommissioning Trust (NDT) to cover 15 years of ISFSI operations (as well as all other projected decommissioning costs). In addition, MYAPCO has the right to resume collection of decommissioning charges from its customers subject to the submittal of a proposal under section 205 of the Federal Power Act, if needed.

MYAPCO has an account within its NDT entitled, "ISFSI Radiological Decom," that segregates the funds for radiological decommissioning of the ISFSI from the larger balance of funds for ongoing management of spent fuel and GTCC waste held in the NDT.

The assumptions of the current decommissioning cost estimate are discussed in the Decommissioning Funding Plan submitted to the NRC on December 16, 2015 in accordance with 10 CFR 72.30(c) (Reference 7.3-1). The decommissioning cost estimate incorporates the most recent assumptions with respect to the remaining decommissioning activities and related costs (i.e., those associated with the Maine Yankee ISFSI). The total un-escalated cost estimate for decommissioning the ISFSI, including contingency is approximately \$27.4 million and \$28.1 million in 2015 and 2016 dollars, respectively. This includes approximately \$21.6 million and \$22.1 million for radiological removal in 2015 and 2016 dollars, respectively and approximately \$5.9 million and \$6.0 million for

non-radiological removal in 2015 and 2016 dollars, respectively.

MYAPCO will continue to inform the NRC regarding the status of this funding by complying with the obligations defined in: 1) 10 CFR 50.75(f)(1) and (2) to submit an annual Decommissioning Funding Status Report; 2) 10 CFR 50.82(a)(8)(v) to submit an annual financial assurance status report regarding decommissioning funding; and 3) 10 CFR 72.30(c) to resubmit the decommissioning funding plan at intervals not to exceed three years.

### 7.3 References

- 7.3-1 Letter from C. Pizzella (MYAPCO) to U.S. Nuclear Regulatory Commission, OMY-15-053, "Three-Year Update to the Independent Spent Fuel Storage Installation Decommissioning Funding Plan," dated December 16, 2015.



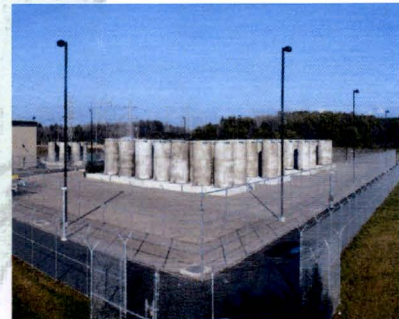
**ENCLOSURE 2 TO OMY-17-006**

**REVISION 9 TO MAINE YANKEE  
LICENSE TERMINATION PLAN**

# License Termination Plan

Revision 9      February 2017

Submitted by:  
Maine Yankee Atomic Power Company



**Attachment 1 – Listing of Key Changes - License Termination Plan, Revision 9**

<b>Section</b>	<b>Proposed Change</b>	<b>Reason for Change</b>
Chapters 3, 7, and 8	Incorporate updated decommissioning Cost Estimate and schedule	In November 2016, FERC approved a new decommissioning cost estimate and schedule that was submitted by MY on September 30, 2016.

**Attachment 2 – List of Effective Pages – License Termination Plan, Revision 9**

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Attachment 6-7	3	
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Attachment 6-11	3	
Attachment 6-12	3	
Attachment 6-13	4	
Attachment 6-14	3	
Attachment 6-15	3	
Attachment 6-16	3	Replaced by Attachment 2H
Attachment 6-17	4	Deleted
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**MAINE YANKEE**

**PREFACE**

**LICENSE TERMINATION PLAN REQUIREMENTS -  
A NON-TECHNICAL SUMMARY**

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## **P.0 LICENSE TERMINATION PLAN REQUIREMENTS - A NON-TECHNICAL SUMMARY**

### **P.1 Introduction**

Maine Yankee received feedback from a number of different stakeholders concerning plans for license termination and releasing the site for other uses. These stakeholders include the Maine Department of Environmental Protection, Department of Human Services Division of Health Engineering, the State Nuclear Safety Advisor, the Governor's Technical Advisory Panel, the Maine Yankee Community Advisory Panel, the Environmental Protection Agency, town of Wiscasset officials, Friends of the Coast, and various private individuals.

The feedback has generally indicated a desire for Maine Yankee to go beyond the NRC regulatory requirements (including ALARA) in reducing residual radiation exposure on-site. To that end, in the Preface to the Original License Termination Plan submitted on January 13, 2000, Maine Yankee proposed a site release standard of not more than 10 mrem/year for all pathways, including not more than 4 mrem/year from groundwater sources of drinking water. On April 26, 2000, the Governor of the State of Maine signed into law LD 2688-SP1084, "An Act to Establish Clean-up Standards for Decommissioning Nuclear Facilities." This legislation amended the Maine State definition of Low Level Radioactive Waste to exclude radioactive material remaining at the site of a decommissioned nuclear power plant if the enhanced state standards described in the new law are met. Prior to the passage of this legislation, on April 14, 2000, Maine Yankee had signed an agreement with several Maine groups to support this legislation and to fulfill our mutual intent to reduce the radiological burden at the Maine Yankee site. These groups included "Safe Power for Maine," "Citizens Against Nuclear Trash," "Friends of the Coast - Opposing Nuclear Pollution," and the Town of Wiscasset. The state law and the agreement identified above go beyond the NRC regulatory requirements in reducing residual radioactive contamination remaining on-site at license termination.

This section of the LTP has two purposes:

- To discuss key elements of the LTP while lending perspective with respect to public health and safety and
- To review the steps beyond the NRC regulatory requirements Maine Yankee will implement in being responsive to stakeholder feedback and state legislation. These steps are factored into Sections 1 through 9 of the License Termination Plan.

This Preface of the LTP is not intended for the NRC. Rather it is directed to the wide audience of readers who have a stake or an interest in the ultimate re-use of the Maine Yankee site.

## P.2 Background and Definitions

NRC regulations require that decommissioning nuclear facilities clean up residual radioactivity (i.e., plant derived radioactive contamination above natural background radiation) so that the average member of the critical group would receive no more than a 25 millirem (mrem) dose over a year's period of time. This is total dose from any exposure pathway (e.g., drinking water, food, etc.). The enhanced state clean-up standard requires that this residual radioactivity result in not more than 10 mrem/year for all pathways, including not more than 4 mrem/year from groundwater sources of drinking water.

Dose is a measure of exposure to radioactivity. Naturally occurring radioactivity in Maine - i.e., from rock and minerals such as granite or from cosmic radiation - amounts to about 200-300 mrem/year. People are routinely exposed to many other sources of radioactivity.

In addition to the NRC's site release limit, the NRC also requires that the residual radioactivity be ALARA - "As Low As Reasonably Achievable." Using NRC guidance, "reasonably achievable" is determined by the amount of dose reduction achieved compared to the cost of additional dose reduction.

The Environmental Protection Agency (EPA) has also issued site release guidance for facilities other than commercial nuclear power plants. Their criterion is risk-based rather than dose-based. Without accounting for radioactive decay, the EPA calculates a "surrogate" limit of 15 mrem/year which, when decay is accounted for, results in guidance in excess of 30 mrem/year. The EPA also fosters an additional criterion of 4 mrem/year due to groundwater ingestion. The EPA does not have an ALARA standard.

Dose in this range (4 -25 mrem per year above background) is such a low value that it cannot be directly measured, particularly considering that total radiation exposure is the sum of many different exposure pathways such as eating, drinking and direct exposure.

In order to demonstrate compliance with a dose limit, one must convert it to a surrogate value that can be directly measured. This value is called Derived Concentration Guideline Level or "DCGL." The DCGL is a limit for residual radioactive contamination levels in soil, buildings, etc. that, when put into a computer model to account for all exposure pathways, will result in doses not more than a pre-defined limit (e.g., not more than 10 mrem/year for all pathways, including not more than 4 mrem/year from groundwater sources of drinking water).

In order to identify the exposure pathways, one must answer the question, "Who receives the dose?" The answer is found in regulatory guidance which requires the dose calculations to model the average member of the critical population group. In other words, a hypothetical, conservative scenario is created which includes theoretical individuals who could receive more radiation dose than could be expected for a member of the public.



As a result, Maine Yankee has chosen the so-called resident farmer scenario. In this case, a farmer is resident on the site, obtains drinking and irrigation water from the most contaminated portion of the site, and eats the crops and animals grown from the well water. As discussed in more detail in the LTP, this is an extremely conservative scenario because high quality community water service is readily available, and a resident farmer is unlikely to inhabit the property given the potential for certain commercial uses.

All of the exposure pathways applicable to the resident farmer scenario are considered in the computer model. This model results in the calculation of the DCGL. The DCGL is a value that can be directly measured. For instance, the residual contamination on a building foundation wall may be 15,000 dpm/100 cm<sup>2</sup>. The term "dpm" stands for "disintegrations per minute" and is the number of radioactive atoms that decay in a minute. The "100 centimeter squared" provides an area over which the measurement is made. If the DCGL for this building example is below 18,000 dpm/100 cm<sup>2</sup> (e.g., in the Containment Building) then, under "MARSSIM" (see below), we can be assured that radiation exposure due to this portion of the building, combined with the remainder of the site, will be not more than 10 mrem/year for all pathways, including not more than 4 mrem/year for groundwater sources of drinking water.

Once the dose limit is converted to a readily measurable value, the question is "How should one measure it in a widely recognized manner with high confidence that the site meets the limit for release?" To solve this problem, various government agencies including the NRC, the EPA, the Department of Energy and the Department of Defense spent a number of years pooling their resources to come up with a solution. They developed a method that would ensure, on a rigorous statistical basis with a high degree of confidence, that any site areas to be released meet the site release criteria. These methods were published in December, 1997 under the title "Multi-Agency Radiation Survey and Site Investigation Manual," or MARSSIM for short. NRC and EPA recommend, and Maine Yankee has committed to, the use of MARSSIM.

### P.3 Relationship Between the LTP and Site Cleanup Levels and Doses

The LTP's primary purpose is to demonstrate compliance with the NRC's annual dose limit of 25 mrem plus ALARA and the enhanced state clean-up levels of not more than 10 mrem/year for all pathways, including not more than 4 mrem/year from groundwater sources of drinking water. Due to conservatism employed in demonstrating compliance, the ultimate site cleanup level will be lower.

Under NRC guidance and MARSSIM, Maine Yankee assumes that the site and buildings are contaminated. For dose calculation purposes, we further assume the contamination is everywhere at the DCGL limit. (Remember that the DCGL is that measured value that ensures that dose to the average member of the critical group is not more than 10 mrem/year for all pathways including not more than 4 mrem/year from groundwater sources of drinking water.)

In general, remediating higher contamination levels combined with pre-existing low contamination levels will result in actual contamination levels being a medium to small fraction of DCGLs. Recognizing that contamination levels lower than DCGLs translate directly into lower doses, we can also say that dose to the resident farmer will most likely be a medium to small fraction of 10 mrem/year for all pathways, including not more than 4 mrem/year from groundwater sources of drinking water.

In this sense, the LTP and the associated DCGLs are founded on very conservative assumptions only useful for proving prior to decommissioning that Maine Yankee's approach will meet regulatory requirements.

#### P.4 Additional Information

As discussed at the outset, this Section of the LTP is provided for stakeholders other than the NRC. It is intended to provide a point of reference and perspective on license termination issues associated with public health and safety. Additional information is available through several means: raising questions during meetings of Maine Yankee's Community Advisory Panel; reviewing Maine Yankee's web site at [www.maineyankee.com](http://www.maineyankee.com); written correspondence via mail or e-mail; or simply contacting us at:

ISFSI Manager  
Maine Yankee Atomic Power Company  
321 Old Ferry Road  
Wiscasset, Maine 04578  
(207) 882-1300

Please feel free to use whatever communications means is available, and we'll do our best to answer your question.

**MAINE YANKEE**  
**LTP SECTION 1**  
**GENERAL INFORMATION**

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Figure 1-1

Location of Population Centers With Respect to Location of Maine Yankee

### ATTACHMENT 1A

Maine Yankee Decommissioning Supplementary Radiological Characterization and Analysis Agreement

## 1.0 GENERAL INFORMATION

### 1.1 Introduction

This License Termination Plan (LTP) has been prepared by the Maine Yankee Atomic Power Company (MYAPC) nuclear power plant located at 321 Old Ferry Road, Wiscasset Maine, 04578. For the location of the plant with respect to population centers see Figure 1-1. The site boundary is defined in MYAPC Defueled Safety Analysis Report (DSAR) Figure 2.1-1. In accordance with requirements of 10 CFR 50.82(a)(9), the LTP has been prepared and submitted as a supplement to the DSAR and is intended to support an application for amendment of license number DPR-36; Docket Number 50-309. An application for amendment of the license has been provided to facilitate authorization/approval of the LTP as required by 10 CFR 50.82(a)(9).

The license condition includes a LTP change process similar to that required for the DSAR. The LTP will be updated in accordance with 10 CFR 50.71(e).

### 1.2 Operating and Decommissioning History

The plant is owned by a consortium of New England electric utilities representing consumers in Maine, New Hampshire, Vermont, Massachusetts, Connecticut and Rhode Island. It began commercial operation in December 1972 under Atomic Energy Commission Docket No. 50-309, License No. OL-FP DPR-36, and last operated in December 1996 (Certification of cessation of operation under 10 CFR 50.82(a)(1) submitted August 7, 1997). Over its lifetime, the plant operated for a total of approximately 16 effective full power years based on its rated thermal power. The Maine Yankee board of directors voted to permanently cease further operation and decommission the plant in August 1997. On August 27, 1997, Maine Yankee submitted the Post Shutdown Decommissioning Activities Report (PSDAR). On November 6, 1997, a public meeting was held in Wiscasset to hear public comments on the PSDAR. On November 3, 1998, Maine Yankee submitted the Site-Specific Decommissioning Cost Estimate along with a PSDAR Update.

On October 20, 1997, Maine Yankee submitted a request to revise the Technical Specifications to reflect the permanently defueled status of the plant. On March 30, 1998, the Nuclear Regulatory Commission (NRC) issued Amendment #161 approving those revised Technical Specifications. This amendment revised the Maine Yankee Technical Specifications to reflect the permanently defueled condition of the plant, and regulatory requirements and operating restrictions to ensure the safe storage of spent fuel.

The Final Safety Analysis Report (FSAR) was revised to reflect the permanently defueled plant condition and was re-titled "Defueled Safety Analysis Report" (DSAR). The DSAR

was submitted to the NRC on February 6, 1998 and has since been revised in accordance with 10 CFR 50.71(e). Additional licensing basis documents were also revised and submitted to reflect the plant's defueled condition (Defueled Security Plan, Fire Protection Plan, QA Plan, Training Plan and Emergency Plan).

On January 13, 2000, Maine Yankee submitted the original version of the LTP in accordance with 10 CFR 50.82(a)(9). This submittal was preceded by meetings with the NRC and other federal, state and local stakeholders. Draft copies of the Maine Yankee LTP had been circulated and docketed to enhance dialogue and encourage feedback. On March 16, 2000, the NRC completed its acceptance review of the LTP and determined that the LTP provides sufficient information for the staff to proceed with its detailed technical review. Accordingly, a public meeting was held at the Wiscasset High School on May 15, 2000 to solicit public comments. On May 17, 2000, the NRC published notice of the license amendment application proposing to authorize the LTP in the Federal Register (65FR31357-31358).

In an effort meet stakeholder expectations that site cleanup be conducted to the highest reasonable standards and beyond current federal regulatory requirements if feasible, Maine Yankee made a commitment in the original LTP preface to achieve a clean up of the site to a dose of less than 10 mrem for all pathways and less than 4 mrem to groundwater pathway. Nevertheless, on April 26, 2000, the Governor of the State of Maine signed into law LD 2688-SP1084 "An Act to Establish Clean-up Standards for Decommissioning Nuclear Facilities." This legislation amended the Maine State definition of Low Level Radioactive Waste to exclude, from that definition, radioactive material remaining at the site of a decommissioned nuclear power plant if the enhanced state standards described in the new law are met. These enhanced state standards include dose-based residual radioactivity limits of 10 mrem/year (mrem/yr) or less for all pathways and 4 mrem/year or less for groundwater drinking sources and other limits for construction demolition debris. Prior to the passage of this legislation, on April 14, 2000, Maine Yankee had signed an agreement with several Maine groups to support this legislation and to fulfill our mutual intent to reduce the radiological burden at the Maine Yankee site. These groups included "Safe Power for Maine," "Citizens Against Nuclear Trash," "Friends of the Coast - Opposing Nuclear Pollution" ("Friends of the Coast"), and the Town of Wiscasset. The implementation of the state law and the agreement identified above are both described in detail in Section 6 of this LTP.

In a letter dated May 9, 2000, the NRC requested that Maine Yankee describe what action it would take in response to the new state legislation. In a letter dated June 8, 2000, Maine Yankee generally explained the expected impact of the newly enacted legislation and indicated that Maine Yankee was continuing a dialogue with state agencies and other stakeholders concerning the end state of the site, verification of cleanup to state standards and other issues.

On June 15, 2000, the Friends of the Coast submitted a petition to intervene and a request for a hearing. On June 16, 2000, the State of Maine submitted a petition to intervene and a request for a hearing or, alternatively, to participate as an interested state. Accordingly, on July 7, 2000, an Atomic Safety and Licensing Board (ASLB) was established. During a telephone conference on July 20, 2000 with the participants in the LTP license amendment proceeding, Maine Yankee stated that it intended to submit a revised LTP addressing a number of new matters and suggested that the proceeding be held in abeyance until the revised LTP is filed. The other participants generally agreed with this suggestion. Accordingly, on July 20, 2000, the ASLB issued an order for, among other things, Maine Yankee to file a revised LTP by October 31, 2000 or on November 1, 2000 submit a status report.

During the summer and fall of 2000, Maine Yankee received over 400 comments on the LTP from a range of stakeholders. Many of these comments led to changes which have been included in Revision 1 to the LTP<sup>1</sup>. In addition, Maine Yankee initiated and participated in two facilitated stakeholder meetings on decommissioning topics including the disposition of above grade concrete. As a result of these meetings, Maine Yankee agreed to remove and dispose of offsite the concrete debris which results from the demolition of buildings above three feet below grade. The effects of this agreement have led to additional changes to dose models, final status survey methodology, ALARA evaluations, and dismantlement activities which have been included in this revised LTP.

On October 31, 2000, Maine Yankee submitted to the NRC a status report including Maine Yankee's current best estimated schedule for submitting the revised LTP and progress in settling outstanding matters with stakeholders. Efforts associated with incorporating the above agreements and stakeholder comments resulted in the call for additional data collection and analysis. Based on these efforts and the desire to continue a responsive dialogue with stakeholders, Maine Yankee estimated that the revised LTP would be submitted to the NRC by April 15, 2001. On January 29, 2001 and April 3, 2001, Maine Yankee submitted status reports updating the Board on Maine Yankee's interactions with stakeholders. In the latter report, Maine Yankee extended the revised LTP submittal schedule to June 1, 2001. Accordingly, on June 1, 2001, Maine Yankee submitted LTP Revision 1.

On October 13, 2000 and again on February 5, 2001, the NRC issued requests for additional information (RAI). On August 8, 2001 (following the issuance of Revision 1 of the LTP on June 1, 2001), Maine Yankee submitted responses to the NRC RAIs of

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<sup>1</sup> "Revised LTP" or "original LTP" will be used in the text where needed for clarity; however, in general, "LTP" is intended to mean the revised LTP in all references in this document subsequent to this point.

October 13, 2000 and February 5, 2001. Many of the RAI issues were incorporated, as appropriate, into Revision 1 of the LTP.

On June 8, 2001, Maine Yankee submitted a joint request to the ASLB for a ten-week period for LTP settlement discussions. On July 12, 2001, Maine Yankee provided responses to the State of Maine and Friends of the Coast comments and questions on the LTP. On August 13, 2001, Maine Yankee submitted LTP Revision 2 incorporating many of the remaining NRC, State of Maine and Friends of the Coast issues, as appropriate. On August 31, 2001, the State of Maine, Friends of the Coast, and Maine Yankee reached a Settlement Agreement (SA) related to the ASLB issues. The SA eliminated the need for an ASLB hearing and established a framework for the Parties to resolve the remaining issues. On October 2, 2001, the ASLB issued an order approving the Settlement Agreement and terminating the proceeding.

One item of the SA was the establishment of a Technical Issue Resolution Panel (TIRP). The TIRP consisted of two members each from the State of Maine and Maine Yankee. The TIRP met several times between September 26 2001 and December 13, 2001. On December 13, 2001 the Team reached consensus on the five issues on it's agenda, and issued a Participant Settlement Agreement. The results of the TIRP consensus have been incorporated in Revision 3 of the LTP.

On December 18, 2001 and January 17, 2002, the NRC issued a further round of RAIs on LTP Revision 2. On March 13, 2002, Maine Yankee responded to the RAIs. As appropriate, the resolution of the RAIs were incorporated in Revision 3 of the LTP. LTP Revision 3 was submitted on October 15, 2002.

Three addenda letters were submitted to the NRC: (1) MN-02-058, LTP Revision 3 Addenda dated November 21, 2002 - Clarifications and Minor Corrections to Maine Yankee License Termination Plan Revision 3; (2) MN-02-061, dated November 26, 2002, Maine Yankee License Termination Plan, Rev. 3 Addenda and Additional Information Related to the Eberline Model E600 Instrument; (3) MN-02-063, dated December 12, 2002, Update on Forebay Dike Coring Results and Associated Changes to LTP Attachment 2H (LTP Revision 3 Addenda).

On February 28, 2003, the NRC issued Amendment 168 to the MY Facility Operating License; approving and incorporating LTP Revision 3, and associated addendum, into the MY License. Maine Yankee provided comments on the Amendment 168 Safety Evaluation in letter MN-03-023, dated May 6, 2003.

On September 11, 2003, Maine Yankee submitted letter MN-03-049 to the NRC proposing a change to the activated concrete DCGL using more realistic activated dose



modeling. On February, 18, 2004, NRC issued Amendment No. 170 approving this change.

On March 15, 2004, Maine Yankee submitted letter MN-04-020 requesting an amendment to the facility operating license pursuant to 10 CFR 50.90 and in accordance with the NRC Approved License Termination Plan (LTP) for Maine Yankee, to acquire NRC's approval of the release of the Non-ISFSI site land from the jurisdiction of the license. From March 2004 to July 2005, Maine Yankee submitted supporting final status survey reports, supplements to the amendment and responses to NRC requests for additional information. On September 30, 2005, NRC issued Amendment No. 172 consisting of the unrestricted release of the remaining land under License No. DPR-36 with the exception of the land where the Independent Spent Fuel Storage Installation (ISFSI) is located and a parcel of land adjacent to the ISFSI.

### 1.3 Plant Description

The plant was a three-loop pressurized water reactor with a power rating of 2,700 Megawatts thermal. It had a Nuclear Steam Supply System supplied by Westinghouse. The secondary plant consisted of three Asea Brown Boveri turbines, one high pressure and two low pressure, coupled with a 950 MVA Westinghouse electric generator and associated auxiliary systems. The site also included ancillary facilities used to support normal plant operations. These facilities consisted of warehouses, administrative office buildings, security structures, an environmental sampling complex, a substation and a fire protection system.

The plant was located on an 820-acre site in Lincoln County, Wiscasset, Maine as indicated in Figure 1-1. Only the land upon which the ISFSI site and an adjacent parcel of land remain under the control of the 10 CFR 50 License. The total land area is approximately 12 acres. The site boundary is indicated in DSAR Figure 2.1-1B. This location is approximately 0.43 miles from the nearest residence and is within 5 miles of the nearest population center, Town of Wiscasset, as shown in Figure 1-1.

### 1.4 LTP Submittal Change and Early Release of Land

#### 1.4.1 LTP Submittal and Changes

Maine Yankee submitted and maintains this LTP as a supplement to the Defueled Safety Analysis Report. On February 28, 2003, the NRC approved the LTP. Maine Yankee's license will authorize and require Maine Yankee to implement and maintain in effect all provisions of the approved LTP. This license termination plan describes an acceptable approach for demonstrating compliance with the radiological criteria for unrestricted use, as defined by 10 CFR 20.1402,

by meeting a site release criteria of 10 millirem TEDE per year over background (all pathways) and 4 millirem (as distinguishable from background) TEDE per year for groundwater sources of drinking water using appropriate dose modeling methods, pathways and parameters and acceptable final radiation survey methods. The LTP describes dose modeling methods, pathways and parameters which produce derived concentration guideline levels (DCGL's) for a given dose based release criteria. The LTP also describes the final radiation survey methods to demonstrate compliance with the DCGL's. The dose based release criteria used in the LTP is the site release criteria, namely 10 millirem TEDE per year over background (all pathways) and 4 millirem (as distinguished from background) TEDE per year for groundwater sources of drinking water in accordance with state law.<sup>1</sup> While it is understood that NRC may not agree with or adopt this criteria, it is expected that NRC will be confirming that compliance with NRC regulations is being demonstrated by meeting this site release criteria. Maine Yankee will certify in its application for license termination that it has met this site release criteria (10/4) and will at that time request NRC to confirm this certification.

Changes requiring NRC approval will be submitted via application for a license amendment in accordance with 10 CFR 50.90.

Pursuant to license condition 2.B (10) of Maine Yankee's Facility Operating License No. DPR-36, the licensee may make changes to the LTP without prior approval provided the proposed changes do not:

- a. Require Commission approval pursuant to 10 CFR 50.59;
- b. Violate the requirements of 10 CFR 50.82(a)(6);
- c. Reduce the coverage requirements for scan measurements;
- d. Increase the radioactivity level, relative to the applicable derived concentration guideline level, at which an investigation occurs; or
- e. Increase the probability of making a Type I decision error.

Maine Yankee will submit an updated License Termination Plan in accordance with 10 CFR 50.71(e).

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<sup>1</sup> LD 2688-SP 1084, "An Act to Establish Clean-up Standards for Decommissioning Nuclear Facilities," enacted on April 26, 2000.

Items a and b of the above LTP change criteria regarding 10 CFR 50.59 and 50.82(a)(6) are established in current regulation. Item c regarding the coverage requirements for scan measurements, is established in LTP Section 5.4.1, Table 5-3. Item d regarding investigation levels, sets a limit on the action thresholds that would trigger an investigation. These thresholds are specified in LTP Section 5.6, Table 5-7. Item e limits the probability of releasing a survey unit, which contains residual radioactivity above the release criterion. This probability value is discussed in LTP Section 5.4.2 and 5.8.1.

As appropriate, Maine Yankee will evaluate changes to the LTP using the Data Quality Objective (DQO) process outlined in NUREG-1575, "Multi Agency Radiological Survey and Site Investigation Manual" and/or the considerations described in section 3.2. Changes to the LTP not requiring NRC approval will be submitted as an updated supplement to the DSAR in accordance with 10 CFR 50.71e.

In addition to the above license condition LTP change criteria, Maine Yankee will notify the State of Maine promptly prior to making a change to the LTP that would result in an increase, of any amount, in a Derived Concentration Guideline Level (DCGL) and will request NRC approval if a change to the LTP would result in an increase in a DCGL, as specified in Table 6-11, by more than a factor of two. Note that any DCGL increase is only allowable provided the resulting "Total Annual Dose" remains less than or equal to 10 mrem/y and the "Drinking Water" (dose) remains less than or equal to 4 mrem/y (as presented Table 6-11). In other words, the individual contaminated material DCGLs listed in Table 6-11 must always collectively result in a total annual dose of 10 mrem/y or less and a drinking water dose of 4 mrem/y or less. As discussed above, Maine Yankee will certify in its application for license termination that it has met this site release criteria (pursuant to license condition 2.B (10) of Maine Yankee's Facility Operating License).

In the event that Maine Yankee elects to reduce a survey unit's classification as listed in Section 5, i.e., from Class 1 to Class 2 or 3, or from Class 2 to 3, prior notification will be provided to the NRC. Criteria for reclassification is discussed in Section 5.6.4. Maine Yankee will provide the NRC as much early notice of this decision as practical but not less than two weeks. (See Reference 1.7.16.)

#### 1.4.2 Phased Release and License Termination

Maine Yankee will make changes to the site boundary footprints to allow unrestricted release and license termination of parcels of property. The following process will be used for making these changes:

- a. Following the completion of LTP activities in a given area, Maine Yankee will provide to the NRC a license amendment request covering the area which it seeks to release from the Part 50 license. This report will contain the information which the NRC needs to make a determination similar to 10 CFR 50.82(a)(11) and will include:
  1. A description of the boundaries associated with the area to be released.
  2. A statement that the remaining dismantlement activities for the affected area described in the license termination plan have been performed.
  3. Final Status Survey (FSS) results for the area. FSS is not required for non-impacted areas.
  4. An evaluation of the potential for possible re-contamination of the area and a description of the specific controls established to prevent re-contamination.
  5. An evaluation of the impact on the exclusion area for the site lands remaining within the domain of the Part 50 license.
  6. An evaluation of the potential combined dose effects on the critical group at license termination as a result of partial releases of land
  7. An evaluation of the impact on the following license programs for the site lands remaining within the domain of the Part 50 license: Offsite Dose Calculation Manual (ODCM), Emergency Plan, Security Plan, Fire Protection Plan, QA Plan, Training Plan, DSAR, and Post Shutdown Decommissioning Activities Report (PSDAR).

8. A no significant hazards determination evaluation.

This process has been informed by NRC Regulatory Issue Summary 2000-19 "Partial Release of Reactor Site for Unrestricted Use Before NRC Approval of the License Termination Plan."

Upon satisfactory NRC review, the NRC will provide a license amendment to Maine Yankee that the NRC has made the required 10 CFR 50.82(a)(11) and 50.91 determinations regarding the area to be released from the Part 50 license and that the area is henceforth released from the Part 50 license. This license amendment will carry the same authority as that associated with terminating a license under 10 CFR 50.82(a)(11).

- b. Once an area is so released, it is understood that the NRC will not require additional surveys or decontamination of these areas by Maine Yankee in response to future NRC criteria or standards, new information or third party survey results, unless, similar to 10 CFR 20.1401(c), the NRC determines that the criteria of 10 CFR Part 20, Subpart E were not met and residual activity remaining at the site could result in significant threat to public health and safety. With regard to each release, Maine Yankee will work with the NRC and the State of Maine in facilitating confirmatory surveys.
- c. Maine Yankee anticipates a three-phased release of land from the operating license:
  - 1. Approximately 641 acres of land associated with the Eaton Farms and the land north of Ferry Road. A portion of this land will be transferred for the purpose of an environmental center in accordance with the FERC rate case settlement.

Reference: Maine Yankee to USNRC letters dated August 16, 2001 (MN-01-034) Early Release of Backlands (Combined), Proposed Change No. 211, Supplement No. 1, and November 19, 2001 (MN-01-044) same subject, Proposed Change No. 211, Supplement No. 2.

Approval: The NRC provided approval of the subject request for release of site lands by issuance of the license

amendment granted by the NRC letter to Maine Yankee, dated July 30, 2002, Issuance of Amendment No. 167.

2. The remainder of the site not associated with the ISFSI

Reference: Maine Yankee to USNRC letter dated March 15, 2004 (MN-04-020) "Release of Non-ISFSI Site Land" as supplemented by letters dated September 2, 2004 and May 16, 2005.

Approval: NRC letter dated September 30, 2005, Issuance of Amendment No. 172.

3. The portion of the site associated with the ISFSI and a parcel of land adjacent to the ISFSI.

## 1.5 Plan Description

### 1.5.1 General Information

This section summarizes each of the seven (7) LTP sections required by 10 CFR 50.82(a)(9)(ii).

### 1.5.2 Site Characterization

Section 2 summarizes the radiological surveys that have been conducted to characterize the nature and extent of contamination at Maine Yankee.

A site radiological characterization was performed to support decommissioning planning during November 1997 through March 1998. This resulted in GTS Duratek's "Characterization Survey Report for the Maine Yankee Atomic Power Plant." Following the initial characterization effort, additional data was required and collected (referred to as "continuing characterization"), as discussed in Section 2.1. Additional characterization will be performed as required to support the decommissioning of the ISFSI and associated areas. The site characterization results have been and will be used to identify areas of the site that are likely to require remediation, to plan remediation strategies, and to support final status survey and dose assessment activities.

### 1.5.3 Identification of Remaining Site Dismantlement Activities

Section 3 presents the sequence of dismantlement and decontamination (D&D) activities for the remaining systems, structures, and components at Maine Yankee.

The overall project schedule identifies the remaining site dismantlement activities. The only decommissioning activities that remain are those associated with the ISFSI and adjacent parcel of land. The decommissioning cost estimate assumes that the ISFSI storage pads and Vertical Concrete Casks will be demolished and disposed of as low-level radioactive waste. The extent to which these activities are expected to be conducted under 10 CFR 50.59 is described. The final state of the site, including any underground remnants, is also described.

The strategies for disposal of waste generated during decommissioning are discussed including the disposition of the materials from above grade structures which will be demolished. These strategies include the removal of radioactive material from the site in order to meet the radiological release criteria of 10 CFR 20.1402 and the state clean-up standards. These state clean-up standards specify, among other things, that any construction demolition debris (CDD), including concrete, disposed of at the site meets the limits specified in Table 1 in the 1974 United States Atomic Energy Commission (AEC) Regulatory Guide 1.86. However, Maine Yankee does not expect to dispose of CDD on site.

This section also includes: estimates of the quantity of radioactive material to be released; control mechanisms; and radioactive waste characterization.

A detailed description of the coordination of activities, requirements, permits and licenses covered by other regulatory agencies is included. These activities, requirements, permits and licenses include Comprehensive Environmental Response, Compensation and Liabilities Act (CERCLA), Resource Conservation and Recovery Act (RCRA), Site Location of Development Permitting, Natural Resources Protection Act (NRPA), Solid Waste Storage and Disposal Permits, Hazardous Waste Storage and Disposal Permits, National Pollution Discharge Elimination System (NPDES) Permits, Waste Discharge Licensing, Tank Closure Certification, Stormwater Management, Erosion and Sedimentation Control, Asbestos and PCB characterization and remediation, Noise Regulations, Air Emissions License, etc. These efforts involve coordination between Maine Yankee and other stakeholders including: the Maine Department of Environmental Protection, the Maine Department of Health and Human Services including the State Nuclear Inspectors, the Governor's Nuclear Safety Advisor, the Governor's Technical Advisory Panel, the Advisory Committee on Radiation and Nuclear Waste, etc. In addition to describing the coordination of the efforts

described above, this section of the LTP also describes the various agreements between Maine Yankee and the State of Maine and other parties.

For the purpose of this LTP, it is assumed that the installation and operation of an Independent Spent Fuel Storage Installation will be conducted, separate from the LTP, under a general license which has already been issued in accordance with 10 CFR 72.210. However, the decommissioning of the ISFSI is described in this section. If Maine Yankee submits an application for a 10 CFR Part 72 specific license, this LTP will be revised to eliminate from its scope the decommissioning of the ISFSI.

#### 1.5.4 Remediation Plans

The methods used to reduce the levels of radioactivity to meet the radiological release criteria of 10 CFR 20.1402 (Radiological Criteria for Unrestricted Use) and the enhanced state cleanup standards are described in Section 4. The calculations used to verify that the residual activity levels have been reduced to levels that are as low as reasonably achievable (ALARA) are presented. These calculations, and the applied methodology generally conform to the guidance provided in Draft Regulatory Guide DG-4006 or as superseded by NUREG-1727, "NMSS Decommissioning Standard Review Plan (SRP) [Demonstrating Compliance with the Radiological Criteria for License Termination]."

#### 1.5.5 Final Status Survey (FSS)

Section 5 of this LTP describes the methods that will be used by Maine Yankee to demonstrate that residual contamination levels at the plant site have been reduced to levels below the site release criteria. The derived concentration guideline (DCGL) is calculated in Section 6 of this LTP and represents the residual contamination levels that will result in a Total Effective Dose Equivalent (TEDE) to the average member of the critical population group that is less than 25 mrem per year in accordance with the radiological release criteria of 10 CFR 20.1402 and less than the enhanced state clean-up standards of 10 mrem per year from all pathways and 4 mrem per year from groundwater sources of drinking water. The methods for conducting the final status survey generally follow the guidance in Draft Regulatory Guide 4006 or as superseded by the Standard Review Plan (SRP). NUREG-1575 (Multi-Agency Radiation Survey and Site Investigation Manual [MARSSIM]) is also used to the extent it is referenced in DG-4006 as appropriate. Additional sections of NUREG-1575 are followed as required for specific applications. The FSS plan describes methodology for the division of the site into survey units, the classification of survey areas, and the requirement that all survey units meet the DCGL with a 95% confidence level. Survey areas have



been classified. These survey areas will be divided into survey units as work progresses. Management controls over all aspects of the project are discussed in detail, including quality assurance, data processing, and final status survey reports.

#### 1.5.6 Compliance With the Specified Radiological Criteria for License Termination

Section 6 of the LTP describes the methods used for conducting a dose assessment to develop the DCGLs for demonstrating compliance with the unrestricted use criteria in Subpart E of 10 CFR 20 and the enhanced state cleanup standards established by State of Maine Public Law - LD 2688-SP 1084.

10 CFR 20.1402, "Radiological Criteria for Unrestricted Use," allows termination/amendment of a license and release of a site for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a total effective dose equivalent to an average member of a critical group that does not exceed 25 mrem per year and the residual radioactivity has been reduced to levels that are ALARA. The enhanced state cleanup standards require that the residual radioactivity distinguishable from background radiation will result in a total effective dose equivalent to an average member of a critical group not more than 10 mrem/year for all pathways and 4 mrem/year for groundwater sources of drinking water. In addition, the enhanced state cleanup standards require that any construction demolition debris, including concrete, disposed of at the site meet the limits of Table 1 in the 1974 AEC Regulatory Guide 1.86.

#### 1.5.7 Update of the Site-Specific Decommissioning Costs

Section 7 provides an updated estimate of remaining decommissioning costs and a discussion of the funding mechanism and decommissioning trust. |

#### 1.5.8 Supplement to the Environmental Report

Section 8 satisfies the requirements stated in:

- a. 10 CFR 50.82(a)(9)(ii)(G)  
A supplement to the Environmental Report pursuant to 51.53 describing any new information or significant environmental change associated with the licensee's proposed termination activities.

b. 10 CFR 51.53(d)

*Post operating license stage.* Each applicant for a license amendment authorizing decommissioning activities for a production or utilization facility either for unrestricted use or based on continuing use restrictions applicable to the site; and each applicant for a license amendment approving a license termination plan or decommissioning plan under §§50.82 of this chapter either for unrestricted use or based on continuing use restrictions applicable to the site; and each applicant for a license or license amendment to store spent fuel at a nuclear power reactor after expiration of the operating license for the nuclear power reactor shall submit with its application the number of copies, as specified in §§51.55, of a separate document, entitled "Supplement to Applicant's Environmental Report -- Post Operating License Stage," which will update "Applicant's Environmental Report -- Operating License Stage," as appropriate, to reflect any new information or significant environmental change associated with the applicant's proposed decommissioning activities or with the applicant's proposed activities with respect to the planned storage of spent fuel. Unless otherwise required by the Commission, in accordance with the generic determination in §§51.23(a) and the provisions in §§51.23(b), the applicant shall only address the environmental impact of spent fuel storage for the term of the license applied for. The "Supplement to Applicant's Environmental Report -- Post Operating License Stage" may incorporate by reference any information contained in "Applicants Environmental Report -- Construction Permit Stage."

The purpose of Section 8 of the LTP is to upgrade the Maine Yankee Environmental Report with any new information or significant environmental change associated with Maine Yankee's proposed decommissioning/license termination activities. This section of the LTP constitutes a supplement to Maine Yankee's Environmental Report pursuant to 10 CFR 51.53(d) and 10 CFR 50.82(a)(9)(ii)(G). In October, 1970, Maine Yankee submitted to the US Atomic Energy Commission (AEC: NRC's predecessor) its Environmental Report, which was further appended in February 1971 with supplementary information. On April 19, 1972, Maine Yankee submitted to the AEC a "Supplement to Environmental Report." It is this latest supplement which is being updated by this LTP section pursuant to the above regulations. On July 1972 the AEC issued the Final Environmental Statement related to the operation of Maine Yankee Atomic Power Station.

Any identified new information or significant environmental change associated with Maine Yankee's proposed decommissioning/license termination activities has been evaluated to determine whether it is bounded by the site-specific decommissioning activities described in Maine Yankee's PSDAR or AEC's Final Environmental Statement. Pursuant to 10 CFR 51.53, this supplement identifies any changes in Maine Yankee's decommissioning activities as previously identified in revision of its submittal, and provides the reasons for concluding that the impacts associated with those changes remain bounded by the Final Generic Environmental Impact Report Statement (FGEIS), NUREG-0586.

#### 1.5.9 Special Agreement With Friends of the Coast - Opposing Nuclear Pollution

- a. As a result of its review of the draft revised LTP, Friends of the Coast raised questions regarding the characterization of radioactivity deposition in off-site marine sediment. The plant derived activity is the result of licensed plant effluent releases offsite into the intertidal zone surrounding Bailey Point. A separate agreement was reached between Maine Yankee and Friends of the Coast to conduct a special marine sediment study in the intertidal zone areas with the overall purpose of enhancing public confidence in the decommissioning process. The key elements of this agreement, "Maine Yankee Decommissioning Supplementary Radiological Characterization and Analysis," dated May 31, 2001, are described in this section. The full text of the agreement is included as Attachment 1-A to this section.
- b. It is recognized that the intertidal zone, beyond the site boundary (per the Maine Yankee DSAR Section 2.1 and DSAR Figure 2.1-1A), was an area subject to the periodic discharge of low levels of radioactive effluents, released under the plant's operating license per the regulations governing off-site releases, monitoring, dose assessment, sampling, and reporting [i.e., 10 CFR Part 20, Subpart D, Part 50 Appendix I, and 10 CFR 50.36a(2)]. These discharges were made and evaluated in accordance with the Offsite Dose Calculation Manual and the Radiological Effluent Monitoring Program which are the principal site administrative programs that implement the above requirements. During the period of storage of spent fuel and GTCC waste, there are no discharges. Because this intertidal zone area was beyond the site boundary, addressed by regulations associated with the Part 50 plant license, and involve dose

commitment to the public already assessed by these programs and regulations, the area is not included within the scope of the LTP.

- c. Regardless of regulatory considerations, Maine Yankee recognizes the community interest in future potential public uses of this area. Although all measurements to date have identified intertidal zone levels of radioactivity well below that allowed to be left on-site, Maine Yankee acknowledges a public benefit in enhanced confidence that can be achieved by additional radiological characterization of the intertidal zone near the end of decommissioning.
- d. Per the subject agreement, Maine Yankee worked with Friends of the Coast to contract a radiological survey to characterize the intertidal zone (which is defined in the agreement). This survey was distinct from and in addition to that formerly agreed upon in the partial settlement of the FERC rate case settlement which also provided for a survey of off-site marine sediment (Reference 1.7.12). The intertidal zone characterization included the “non-affected” Eaton Farm location as well as Bailey Point (to an agreed point, south of Ferry Road).
- e. The methods and protocols used in the survey are discussed in the agreement. Dose pathways associated with the intertidal zone, considering current and future uses, were identified and agreed upon between Maine Yankee and Friends of the Coast. The characterization results and dose assessment were reported in a form to allow comparison to appropriate on-site DCGLs established in the LTP and to the resident farmer dose. The Maine Yankee Marine Sampling Study Final Report issued in February 2005 (Reference 1.7.33) concluded that the intertidal zone activities and dose levels were below federal and state limits for site decommissioning.

## 1.6 Maine Yankee LTP Information Contact

For information or comments regarding the Maine Yankee License Termination Plan, please contact the following party:

ISFSI Manager  
Maine Yankee Atomic Power Company  
321 Old Ferry Road  
Wiscasset, Maine 04578  
(207) 882-1303

## 1.7 References

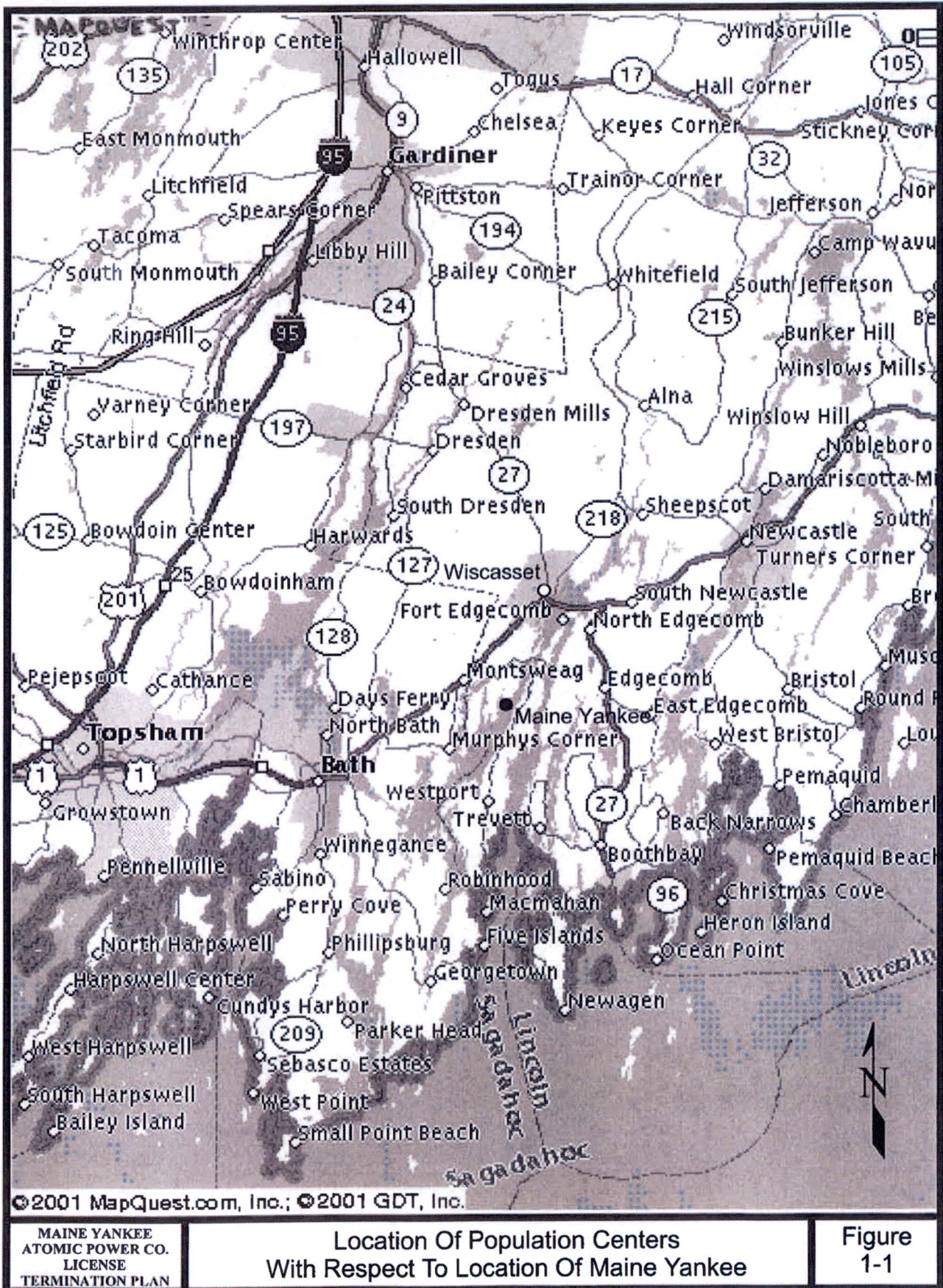
- 1.7.1 NUREG-0586, "Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities".
- 1.7.2 NUREG-1496, Generic Environmental Impact Statement in Support of Rulemaking on Radiological Criteria for License Termination of NRC-Licensed Nuclear Facilities.
- 1.7.3 Maine Yankee Environmental Report, dated October 1970
- 1.7.4 "Final Environmental Statement Related To Operation of MY Atomic Power Station," dated July 1972.
- 1.7.5 Supplement One to the Maine Yankee Environmental Report, dated April 19, 1972.
- 1.7.6 NRC Regulatory Issue Summary 2000-19, "Partial Release of Site for Unrestricted Use Before NRC Approval of the License Termination Plan"
- 1.7.7 GTS Duratek, "Characterization Survey Report for the Maine Yankee Atomic Power Plant," Volumes 1-9, 1998 (ICS).
- 1.7.8 NUREG-1727 "NMSS Decommissioning Standard Review Plan," September 15, 2000.
- 1.7.9 NUREG-1575, "Multi-Agency Radiation Survey and Site Investigation Manual" (MARSSIM), Revision 1 (June 2001)

- 1.7.10 AEC Regulatory Guide 1.86
- 1.7.11 MYAPC Site Specific Decommissioning Cost Estimate, November 3, 1998
- 1.7.12 June 1, 1999 Federal Energy Regulatory Commission approval of rate case settlement agreement, Docket Nos. ER98-570-000, EL98-13-000, and EL98-14-00
- 1.7.13 Post Shutdown Decommissioning Activities Report, Maine Yankee letter to the NRC, MN-97-99, dated August 27, 1997.
- 1.7.14 MYAPC Defueled Safety Analysis Report (DSAR)
- 1.7.15 State of Maine Public Law LD 2688-SP1084 "An Act to Establish Clean-up Standards for Decommissioning Nuclear Facilities", April 26, 2000
- 1.7.16 NRC letter to Maine Yankee, dated August 23, 2002, "Maine Yankee Atomic Power Station re: License Termination Plan Issue" (dealing with survey unit reclassification and the PAB test pit issue).
- 1.7.17 NRC letter to Maine Yankee, dated July 30, 2002, Issuance of Amendment No. 167, license amendment approving partial release of site lands.
- 1.7.18 Maine Yankee letter to the NRC, MN-00-004 dated January 13, 2000, Maine Yankee License Termination Plan
- 1.7.19 Maine Yankee letter to the NRC, MN-01-023 dated June 1, 2001, Revision 1, Maine Yankee's License Termination Plan
- 1.7.20 Maine Yankee letter to the NRC, MN-01-032 dated August 13, 2001, Revision 2, Maine Yankee's License Termination Plan
- 1.7.21 NRC Letter to Maine Yankee, dated December 18, 2001, Request for Additional Information (RAI) for Maine Yankee Atomic Power Station License Termination Plan (TAC No. MA8000).
- 1.7.22 NRC Letter to Maine Yankee, dated January 17, 2002, Request for Additional Information (RAI) for Maine Yankee Atomic Power Station License Termination Plan (TAC No. MA8000).
- 1.7.23 Maine Yankee letter to the NRC, MN-02-011 dated March 13, 2002,

**Response to NRC Request(s) for Additional Information for Maine  
Yankee Atomic Power Station License Termination Plan**

- 1.7.24 MYAPC Letter MN-02-048 dated October 15, 2021, Revision 3, Maine  
Yankee's License Termination Plan**
- 1.7.25 NRC Letter to MYAPC dated February 28, 2003, Issuance of Amendment  
No. 168 to Facility Operating License No. DPR-36 -- Maine Yankee  
Atomic Power Station (TAC No. M8000).**
- 1.7.26 MYAPC Letter MN-0-023 dated May 6, 2003, Maine Yankee's  
Comments on NRC's Safety Evaluation on the Maine Yankee License  
Termination Plan**
- 1.7.27 Maine Yankee Letter to the NRC, MN-02-058, LTP Revision 3 Addenda  
dated November 21, 2002 - Clarifications and Minor Corrections to Maine  
Yankee License Termination Plan Revision 3**
- 1.7.28 MN-02-061, dated November 26, 2002, Maine Yankee License  
Termination Plan, Rev. 3 Addenda and Additional Information Related to  
the Eberline Model E600 Instrument**
- 1.7.29 MN-02-063, dated December 12, 2002, Update on Forebay Dike Coring  
Results and Associated Changes to LTP Attachment 2H (LTP Revision 3  
Addenda).**
- 1.7.30 Maine Yankee letter to NRC (MN-03-049), dated September 11, 2003,  
Proposed Change: Revised Activated Concrete DCGL and More Realistic  
Activated Concrete Dose Modeling - License Condition 2.B.(10), License  
Termination**
- 1.7.31 NRC letter to Maine Yankee, dated February 18, 2004, Issuance of  
Amendment No. 170 to Facility Operating License No. DPR-36 - Maine  
Yankee Atomic Power Station (TAC No. M8000). Activated Concrete**
- 1.7.32 NRC letter to Maine Yankee, dated September 30, 2005, Issuance of  
Amendment No. 172 to Facility Operating License No. DPR-36 - Maine  
Yankee Atomic Power Station (TAC No. M8000) Unrestricted Release**
- 1.7.33 C.T. Hess, G.P. Bernhardt, et.al., Maine Yankee Marine Sampling Study  
Final Report, issued February 2005.**







**ATTACHMENT 1A**

**Maine Yankee Decommissioning  
Supplementary Radiological  
Characterization and Analysis Agreement**

## **Maine Yankee Decommissioning Supplementary Radiological Characterization and Analysis Agreement**

### **Parties:**

This is an agreement between Maine Yankee Atomic Power Company (Maine Yankee) and Friends of the Coast – Opposing Nuclear Pollution (Friends of the Coast).

### **Purpose:**

The purpose of this agreement is to enhance public confidence in the decommissioning process through an independent, professional, comprehensive and scientifically valid radiological survey of the intertidal area adjacent to the Maine Yankee site.

### **Background:**

Maine Yankee and Friends of the Coast agree that Maine Yankee has been lawfully allowed to discharge low levels of radioactive effluents through its licensed pathways. With that understanding, both parties entered into an agreement (copy attached) as a partial settlement of the 1998 FERC rate case, which included provisions for a survey of off-site marine sediments. The present agreement is in addition to the "FERC agreement" and supplements the License Termination Plan by explicitly recognizing, for the purposes of this agreement, the intertidal zone (defined below) as a separate and distinct element of an elective offsite survey

### **Substance:**

Maine Yankee agrees to contract a radiological characterization of the intertidal zone (the present "supplemental agreement") supplementing and in addition to the radiological survey of offsite marine sediment (per the "FERC agreement"). For purposes of economy and efficiency, Maine Yankee will seek a single contractor for both the offsite marine sediment survey and the intertidal zone survey through a single request for proposal (RFP). Nothing in this "supplementary agreement" alters the previous "FERC agreement".

The intertidal zone is that offsite area that lies between the site boundary (as described in the Maine Yankee license basis and the License Termination Plan) and the mean low tide mark of adjacent waters (or an outer bound drawn 100 feet from the high tide mark, whichever is closer). The extent of the intertidal zone to be characterized shall include the designated "non-affected" Eaton Farm location as well as Bailey Point (to an agreed upon point south of Ferry Road).

Dose pathways associated with the intertidal zone current and potential future uses will be identified and agreed upon between Maine Yankee and Friends of the Coast. Characterization results will be used to calculate an incremental intertidal zone dose which may be compared to the limiting "resident farmer" dose calculations in the License Termination Plan. Characterization results will also be reported in a form allowing comparison to on-site DCGLs (e.g., soil) in the License Termination Plan.

**Methods and Media:**

The intertidal zone characterization will be conducted using agreed upon methods and protocols. Upon request, Maine Yankee and Friends of the Coast will observe traditional split sampling protocols with interested parties.

The characterization will be accomplished via:

- Sampling and isotopic analysis of disturbed and undisturbed intertidal zone soils/sediments,
- Sampling and isotopic analysis of flora and fauna that may reasonably be considered contributors to an intertidal zone pathway dose (e.g., seaweed, shellfish, etc.), and
- Selected gamma scan employing high efficiency (e.g., sodium iodide) detectors, or best practical means, for the purpose of identifying discrete or "hot" particles.

**Conditions:**

Maine Yankee and Friends of the Coast will work together to define an RFP for a sampling and analysis plan for the intertidal zone, identify qualified independent contractors to receive the RFP, and select a contractor based on the bids received. Maine Yankee reserves the right to: 1) establish a reasonable ceiling on the cost of the supplemental study consistent with accomplishing the purposes of the study and re-bid as necessary to satisfy that constraint, and 2) void this agreement should issues associated with the intertidal zone, as the intertidal zone is defined in this agreement, become admissible contentions before the ASLB.

Maine Yankee and Friends of the Coast agree to develop the RFP by 12/31/2001 and implement the study following final liquid discharge from spent fuel pool operations (approximately 3/2003).

This agreement, if finalized in sufficient time, will be included in the revised License Termination Plan as an attachment to or in Section I and referenced wherever else Maine Yankee deems appropriate. If the agreement is not finalized before submittal of the revised License Termination Plan, a statement of intent will be placed in Section I and a later License Termination Plan supplement will provide the agreement when finalized.

If hot particles that would exceed remediation thresholds on-site are discovered in the "supplemental characterization", hot particle remediation will be undertaken following on-site methods and protocols.

Results of the "supplemental characterization" will be reported to Maine Yankee and Friends of the Coast. The written report will be publicly available and Friends of the Coast will receive sufficient copies to disseminate to interested parties and members of the public who request copies.

Friends of the Coast, assisted by Maine Yankee, will provide an annotated bibliography of historical records, studies, etc. to be included as an appendix in the "supplemental study" report.

Agreed by:

Original Signed by Wayne Norton for  
Maine Yankee

May 31, 2001  
Date

Original Signed by Ray Shadis for  
Friends of the Coast

May 31, 2001  
Date

**MAINE YANKEE**  
**LTP SECTION 2**  
**SITE CHARACTERIZATION**

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### Maine Yankee Site Characterization Locations of Radiological Survey Packages

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## **2.0 SITE CHARACTERIZATION**

### **2.1 Overview**

The radiological and chemical characterization of the Maine Yankee (MY) site has been going on since pre-operational sampling was begun in 1970. Initial site characterization for decommissioning was begun in the fall of 1997 and ran through the spring of 1998. Historical information, including the 10 CFR 50.75(g) file, employee interviews, Radiological Incident files, pre-operational survey data, spill reports, special surveys (e.g., site aerial surveys, marine fauna and sediment surveys), operational survey records and Annual Radiological Environmental Reports (including sampling of air, groundwater, estuary water, milk, invertebrates, fish and surface vegetation) to the NRC were reviewed and compiled into the Historical Site Assessment (HSA). Using the information collected during the HSA, an overall characterization plan was developed to collect measurements and samples from plant structures, systems and open land areas to cover the areas where contamination existed, remained or had the potential to exist.

The information collected during all phases of site characterization, including the HSA, was used during decommissioning planning to achieve the following objectives:

- Determine the radiological status of the site and facility to include identification of systems, structures, soils and water sources in which contamination exists;
- Identify the location and extent of any contamination outside the radiological restricted areas (RA);
- Estimate the source term and radionuclide mixture to support decommissioning cost estimation and decision-making for remediation, dismantlement and radioactive waste disposal activities;
- Select the instrumentation used for surveys and develop the quality assurance methods applied to sample collection and analysis;
- Perform dose assessment and FSS design; and
- Ensure the Radiation Protection Program addresses any unique radiological health and safety issues associated with decommissioning.

The initial site characterization process focused on four areas, providing both shutdown and current data for structures, systems, radiological environs and hazardous materials environs. The extent and range of contamination were reported for structures, systems, drains, vents, embedded piping, paved areas, water and soils. In addition, activation analyses were performed on key components within the restricted area to estimate radioactive waste volumes and classes.

The initial characterization results (ICS<sup>1</sup>) were provided to MY in the "Characterization Survey Report for the MY Atomic Power Plant," developed by GTS Duratek. After review of this initial characterization report, it was determined that additional sampling was needed to fully define the extent of contamination in some outdoor areas and some systems in order to design the FSS, perform dose assessments and address questions related to waste volumes. This additional sampling, which is generally referred to as Continuing Characterization Surveys (CCS), is discussed in Section 2.5. As additional data is required (such as concrete cores, etc.), characterization samples will be obtained; and will be included as part of the FSS process.

This section summarizes the key findings of the HSA and characterization survey results, as supplemented by continuing characterization. The initial characterization report and the detailed results of continuing characterization, are maintained at the MY site and are available for NRC review. Data from the CCS effort was filed with the appropriate characterization package associated with the system, structure, component, or area being surveyed (or sampled). These packages are maintained in the Plant Technical File System. The level of detail provided in this summary demonstrates that the overall characterization plan objectives listed above have been met. In addition, the characterization data provided in this section are consistent with NRC guidance contained in Regulatory Guide 1.179, "Standard Format and Content of License Termination Plans for Nuclear Power Reactors," and sufficient to meet the review criteria set forth in NUREG-1700, "Standard Review Plan for Evaluating Nuclear Power Reactor License Termination Plans."

As of September 30, 2005, the only decommissioning activities that remain are those associated with the ISFSI. The information included in this section of the LTP includes historical information regarding the decommissioning of the Maine Yankee Nuclear Plant that will be maintained in its current form. This information will be reviewed, and revised as necessary, at the time of initiating the decommissioning activities for the ISFSI and associated land areas to ensure that appropriate information is available for the implementation of final status survey activities for the ISFSI and termination of the Part 50 License for the Maine Yankee site.

## 2.2 Historical Site Assessment

The Radiation Protection organization amassed tens of thousands of survey records documenting general area and component-specific radiation levels, contamination levels, system activity levels and airborne radioactivity levels during 25 years of plant operation. These survey records reflected radiological conditions on site with frequency and detail

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<sup>1</sup> "ICS," as used in the LTP refers to the initial characterization performed by GTS Duratek, as documented in the "Characterization Survey Report for the MYAPP," 1998. It may also simply be referred to as the "GTS Duratek report."

dependent on the magnitude of radiation and contamination present in an area and the frequency with which the area was entered by the operating staff. Plant document files contained records of spill and event reports (Operations Department Unusual Occurrence Reports and Radiation Protection Department Radiological Incident Reports) as well as the required annual or semiannual radiological effluent reports to the NRC which documented any unplanned releases.

In order to ensure a complete discovery of events involving spills, leaks or other operational occurrences which might have an effect on the radiological and chemical status of the site, MY also interviewed terminating employees for any recollection of such events.

#### 2.2.1 Historical Data Review

Historical records contained in the radiation protection files, 10 CFR 50.75(g) file, Annual Radiological Environmental Reports to the NRC, miscellaneous environmental reports, and one 10 CFR 20.302 submittal were reviewed to determine the location and extent of leaks and spills on site. The pertinent results of the record reviews, Initial Site Characterization surveys, and employee interviews were captured in the Historical Site Assessment (HSA). The HSA, as supplemented, is a compilation of the approximately 140 potential events occurring over the 25 year operating history of the plant. About two thirds of these events were potential radiological issues with the other one third being chemical or hazardous material events.

Key items identified in the HSA include:

1. Contaminated soil between the RA and Forebay, from RWST leaks;
2. Contaminated soil after the removal of a low level waste storage area (Wiscasset wall);
3. Location of a silt spreading area/construction debris landfill;
4. A waste neutralization tank drain line leak;
5. A PCC leak in the alley way;
6. Contaminated soil on Bailey Point, south of the Industrial Area (IA) trailer park, in an area where contaminated soil from the PCC leak had been stored;
7. Discrete particles throughout plant from reactor core barrel machining;
8. Contaminated soil in the ISFSI area, formerly known as the contractor parking lot;
9. A discrete particle outside warehouse 2;
10. Contaminated sumps and floor trenches in the turbine hall;
11. RA sink and decon shower drains go to sewage treatment plant;
12. Contaminated sediment in the Forebay;
13. Previous abandonment of an underground ferrous sulfide tank;

14. Snow from RA placed in ball field;
15. Contaminated soil from BWST leaks;
16. Contaminated soils in the IA trailer park; and
17. Very low levels of detectable residual radioactivity on Foxbird Island, RCA building roof, Equipment Hatch pit, and on the concrete block in the ball field dugouts.
18. Two large volume spills in the Containment Spray Building

None of the event records in the HSA indicated the uncontrolled release of radioactive material affecting the site beyond Bailey Point (i.e., south of Ferry Road and east of Bailey Cove).

#### 2.2.2 Decommissioning File 10 CFR 50.75(g)

Even though MY was in operation well before the requirement to maintain a decommissioning file, the 50.75(g) file contained documentation of three areas of soil contamination and one record of a 10 CFR 20.302 submittal for burial in place of residual soil activity. The information in the decommissioning file was added to the HSA so that the affected areas could be properly addressed during site characterization.

The 50.75(g) file documented soils outside the Spray, Containment and Fuel Buildings (see Table 2-1) that were known to contain contamination from an RWST manway leak, a series of RWST siphon heater leaks, SCC/PCC leaks, as well as the storage of radioactive waste awaiting shipment in an outside, shielded storage location. Some work was also performed on contaminated components within tented enclosures located outside the RCA Storage Building which also contributed to soil and pavement contamination.

<p align="center"><b>Table 2-1</b> <b>Significant Soil Contamination Events</b></p>					
<b>Event</b>	<b>Date</b>	<b>Location</b>	<b>Volume</b>	<b>Disposition</b>	<b>Estimated Residual Activity</b>
RWST siphon heater leak	2/23/88	Area south and west of RWST	8200 ft <sup>3</sup>	Remediated 600 ft <sup>3</sup> . 7600 ft <sup>3</sup> left in place under 10 CFR 20.302. <sup>2</sup>	6 mCi
Removal of Low Level Waste Storage Area	7/92	Outside the RCA Storage Bldg and west to high rad bunker	2000 ft <sup>3</sup>	Residual contamination evaluated and entered into 50.75(g) file.	5.9 mCi
Silt spreading area	1992, 1993 Outages	Land adjacent to and south of ballfield.	1250 ft <sup>3</sup>	Residual contamination evaluated and entered into 50.75(g) file.	12 µCi

### 2.2.3 10 CFR 20.302 Submittal (reference Table 2-1 above)

MY applied to the NRC on 11/2/88 (MN 88-107) to allow residual soil contamination to remain in place under the provisions of 10 CFR 20.302. The NRC approved the submittal on 8/31/89. This data is included to provide a complete historical basis for the overall site characterization. The details of the soil contamination are presented below.

In 1988 a small outdoor leak at the inlet flange connection between the RWST siphon heater return line and an isolation valve was discovered and subsequently contained. The actual time that the leak started and the volume of water lost could not be determined. Surveys of the area adjacent to the RWST indicated ground contamination as high as 7E-3 µCi/g of Cs-137.

The leak was repaired, and the contaminated soil was removed from the area and disposed of as radioactive waste. Sample analysis of the soil removed from the area of remediation also indicated the presence of Cs-134, Sb-125 and Co-60 in addition to the Cs-137. The level of activity of these additional nuclides was

<sup>2</sup> 10 CFR 20.302 has been superceded by 10 CFR 20.2002

approximately two orders of magnitude less than the Cs-137. Soil was excavated to a level of two to five feet below grade until the average residual Cs-137 activity had decreased to an equivalent MPC value in water of about  $2\text{E-}5$   $\mu\text{Ci/ml}$ .

Approximately 600 cubic feet of radioactive waste was generated from the excavation. Residual activity of Cs-137 in an estimated 7600 cubic feet of remaining affected soil was 6 mCi. The location of this contaminated soil was known and the need for further remediation was evaluated, via sampling and analysis, during decommissioning to ensure compliance with the unrestricted use criterion. Section 5.5.1.b presents a discussion of deep soil contamination sampling in and near the RWST spill area.

#### 2.2.4 Historical Radiological Status Including Original Shutdown Status

MY ran for approximately 16 full power years, had an early history of fuel clad failures and was known as a high source term plant. Dose rates in the loop areas in Containment were approximately 1000 to 2000 mrem/hr with surface contamination levels averaging in the 10,000 to 100,000 dpm/100 cm<sup>2</sup> range. Routinely-accessed areas of the PAB, Spray and Fuel Buildings had dose rates of 10 to 50 mrem/hr, walkways were kept less than 1000 dpm/100 cm<sup>2</sup>, and equipment spaces had dose rates of up to 1000 mrem/hr and contamination levels on average of 5000 to 50,000 dpm/100 cm<sup>2</sup>. The LSA, RCA Storage and LLWS Buildings had dose rates of 10 to 200 mrem/hr depending on the type and quantity of waste in storage and contamination levels ranged from 5000 to 50,000 dpm/100 cm<sup>2</sup> in liquid waste processing areas to less than 1000 dpm/100 cm<sup>2</sup> in walkways.

Normal system leakage was responsible for the contamination levels found within the Containment, Spray, Fuel and Primary Auxiliary Buildings. Secondary plant areas were kept uncontaminated with the exception of a few components (e.g., component cooling system filters and steam generator blowdown demineralizer) which gave general area dose rates of a few mrem/hr. Primary and secondary component cooling systems were known to contain small amounts of residual Cs-137 from minor heat exchanger leakage which occurred during power operations. The auxiliary boilers and auxiliary condensate receiver also showed evidence of minor contamination from heat exchanger leakage which occurred early in the plant's operating history.

In the late 1980s and early 1990s the plant began measures to reduce both the source term and surface contamination levels. Floor to ceiling area decontaminations were undertaken. High efficiency filters were installed in primary systems. One primary system chemical decontamination was performed which reduced primary system piping radioactivity levels by a factor of two.

In 1990, the plant experienced a primary to secondary steam generator tube leak. Prompt operator actions limited the secondary plant contamination. Following the steam generator tube leak, secondary systems were extensively surveyed during recovery activities and no residual activity was identified. Temporary controlled areas were established in the turbine hall to work on RCP motors, and the turbine hall sumps have indicated detectable plant nuclides.

The plant was shutdown in December 1996 for evaluation of cable separation problems. During the extended outage, economic conditions led to the decision to permanently shutdown in August 1997. A second chemical decon was performed following the decision to decommission the plant. The decontamination factors for the second decon improved to five to ten which resulted in loop area dose rates in the range of 50 to 200 mrem/hr. Contamination levels throughout the plant remained consistent with pre-shutdown values.

#### 2.2.5 Current Radiological Status

All fuel has been removed from the reactor and transferred to the ISFSI. The fuel pool was dismantled and removed for disposal. Chemical and Volume Control System waste resins and filters were removed for disposal. The reactor vessel contained approximately 33,660 gallons of slightly contaminated water. An additional 320,000 gallons added to the refueling cavity for shielding during reactor component removal, was processed as radwaste.

The diffuser remains in place. Characterization of the diffuser is described in Section 2.5.3 and Attachment 2H. Demolition of structures to 3 feet below grade removed the majority of embedded or buried piping. Remaining embedded or buried piping was classified and surveyed in accordance with Sections 2 and 5.

Based on both the Historical Site Assessment and the characterization surveys performed, a large portion of the site located to the West of Bailey Cove and North of the Ferry Road was determined to be non-impacted in the partial site release applications (Maine Yankee Letters dated August 16, 2001 (MN-01-034) and November 19, 2001 (MN-01-044) Early Release of Backlands (Combined) Proposed Change 211, Supplements 1 and 2 respectively). The NRC granted the request license amendment in its letter to Maine Yankee, dated July 30, 2002. (See Attachment 2A and References, Section 2.7.)

Containment and control measures have prevented the release of radioactive material beyond the Bailey Point area as evidenced by no detection of plant-derived radionuclides above background levels in any of the measurements taken in or on the land area West of Bailey Cove and North of the Ferry Road. The same control measures will remain in effect during the decommissioning to prevent migration of contamination into clean or non-impacted areas.



On March 15, 2004, Maine Yankee submitted letter MN-04-020 requesting an amendment to the facility operating license pursuant to 10 CFR 50.90 and in accordance with the NRC Approved LTP for Maine Yankee, to indicate NRC's approval of the release of the Non-ISFSI site land from the jurisdiction of the license. From March 2004 to July 2005, Maine Yankee submitted supporting final status survey reports, supplements to the amendment and responses to NRC requests for additional information. On September 30, 2005, NRC issued Amendment No. 172 consisting of the unrestricted release of the remaining land under License No. DPR-36, with the exception of the land where the ISFSI is located and an adjacent parcel of land. The total land area remaining within the control of the 10 CFR 50 License is approximately 12 acres.

The impacted areas of the site extend from the Ferry Road in a southerly direction down Bailey Point.

#### 2.2.6 Hazardous and Chemical Material Contamination

During its operational lifetime, MY used chemicals typical of steam power-generating facilities. In September 1998, MY had only non-bulk quantities of chemical and solvent waste stored on site awaiting disposal and no mixed wastes were in storage.

Preparation for decommissioning of the plant included removal of hazardous and chemical materials from plant systems. In 1998, 16,000 gallons of sodium hydroxide solution were removed from the spray chemical addition tank (SCAT) and neutralized, and chromates were removed from the water in the neutron shield tank using a totally-enclosed ion exchange resin process. A majority of the asbestos insulation was removed as part of the asbestos abatement project completed in January of 1999. Maintenance chemicals and hazardous materials were removed as specific plant areas were prepared for dismantlement.

Decommissioning of the plant included removal of additional known contaminants in plant systems and structures. Mercury switches, lead components, and PCB light ballasts are some examples of hazardous materials that were removed along with other plant components. Polychlorinated biphenyls (PCBs) found at other nuclear facilities were also present at MY but were limited to painted surfaces and in some cable insulation material. Asbestos abatement occurred during the removal of various components and building materials. Section 3.6 of this LTP describes the coordination of activities with other agencies with regard to these contaminants. Decommissioning of the ISFSI will involve the removal of contaminants, other than radioactive contaminants. The volume of waste associated with other contaminants is expected to be extremely small, when compared to the volume disposed of for the plant.

Over the operational lifetime of the plant, spills to the environment occurred and were generally cleaned immediately. In 1988, the facility experienced a 12,000 gallon chromated water leak from an underground component cooling pipe. Following repair of the leak, monitoring wells were installed and the extent of contamination and the effectiveness of remediation were monitored to the satisfaction of the Maine Department of Environmental Protection (MDEP). In 1991, one of the main transformers shorted and released approximately 200 gallons of transformer oil to the Back River. The spill was remediated to MDEP's satisfaction following the event.

In these areas and throughout the site, MY will continue to work with the EPA and MDEP to demonstrate that areas have been adequately characterized, remediated if necessary, and are sufficiently clean to insure public health and safety. The EPA is supporting the Maine Yankee decommissioning project in several areas. The EPA is enabled by the Resource Conservation and Recovery Act (RCRA) to administer closure of facilities that were hazardous waste generators. Since the State of Maine Department of Environmental Protection has been delegated authority to administer the RCRA program in Maine, EPA is serving in a technical support role for the Maine Yankee site closure. EPA is expected to review all major closure-related documents and advise MDEP on their adequacy.

The EPA also is responsible for the Toxic Substances Control Act (TSCA), which serves as the primary means by which the use and disposal of PCBs and PCB-containing materials are controlled. PCBs were identified above the TSCA limits of 50 parts per million (ppm) in electrical cable sheathing and, in limited areas, paint. These materials were removed for disposal.

The MDEP has been delegated authority, by the EPA, to administer the National Pollutant Discharge Elimination System (NPDES) permit program as authorized by the Clean Water Act. Maine Yankee maintained an NPDES permit during operation.

### 2.3 Site Characterization Survey Methods

As discussed in Section 2.1, the site's initial characterization survey work (ICS) was performed by GTS Duratek and its subcontractor. Continuing Characterization Surveys (CCS) were performed by Maine Yankee, initially supported by the former Decommissioning Operations Contractor (DOC), Stone & Webster (SWEC), and its subcontractor, Radiological Services, Inc. (RSI). The FSS plan was based on this information. These site characterization efforts used similar, but not identical, methods and techniques. These differences are noted within the methods and results sections of this report.

### 2.3.1 Organization and Responsibilities

GTS Duratek (GTS) was the prime contractor for the initial characterization surveys conducted from the fall of 1997 through the spring of 1998. GTS supplied hand-held instrumentation and performed field surveys. Subcontractors provided the following specialized services.

- IT Corporation performed the hazardous materials characterization survey and drive-over scans.
- Duke Engineering & Services performed the activation analysis.
- Canberra Industries provided on-site laboratory instruments.
- Team Associates performed the asbestos characterization.
- Quanterra performed off site laboratory analyses.

Continuing characterization (CCS) activities began in the fall of 1998. Samples were collected and on-site surveys and analyses performed. Laboratory analyses for the hard-to-detect radionuclides were performed by Duke Engineering Services.

### 2.3.2 Characterization Data Categories

Survey categories for initial site characterization (ICS) were designated by GTS as surfaces and structures, systems, and environs (soils, sub-slab soils, sediments and groundwater) for both “affected” and “unaffected” locations based on the likelihood of the area being contaminated. The same designations are used for clarity and ease of comparing data.

#### a. Surfaces and Structures

This category included building interiors and exteriors with associated structures, and, where applicable, the exterior surfaces of plant systems and components because these surfaces have the same potential for residual levels of radioactive material as the building surfaces in which they are located. Surface and structure survey packages also included ancillary buildings and structures. Structural material background measurements were also included in this category. These measurements were intended to determine general background levels for various building materials. If background “reference” area measurements are required for final survey measurements, they will be performed in accordance with Section 5.0.

In total, the survey category included approximately 7,900 measurements in unaffected areas and approximately 6,400 measurements in affected areas. This intentional bias toward unaffected surfaces and structures ensured no unsurveyed or undetected locations were likely to exist. Affected structure surveys included 18 concrete core samples. Because concrete basement surfaces represent the key remaining structures upon license termination, an additional 51 concrete core samples were obtained to improve nuclide data. (See Section 2.5.3 and Attachments 2F and 2G for additional detail on these concrete cores and results.)

b. Systems

This category included interior surfaces of process piping, components, ventilation ductwork, and installed drains and sumps. The levels of radioactive material on the internal surfaces of plant systems and components primarily depend on process operations. Therefore, these survey packages were separate from surface and structure survey packages. Plant system survey packages generally were limited to one plant system.

This survey category included approximately 3,800 unaffected system measurements and approximately 1,050 affected system measurements. Again the surveys were biased toward the unaffected systems to provide a high likelihood of identifying any existing contaminated pipe or component.

Additional systems surveys were conducted in order to bound the extent of contaminated components within non-Restricted Area structures.

c. Environs

Land areas were surveyed and sampled to detect the presence and extent of soil contamination. Approximately one-third of the 820-acre site (original 740 acres + buffer land purchased later) land area received a gamma scan. Measurements taken over the entire property used a grid system to adequately locate survey points. Nearly 300 soil samples were taken, 180 of which were from unaffected areas. One survey package in this category was devoted to obtaining background soil and exposure measurements from an area similar in physical characteristics to, but located several miles from, the site.

A study was performed to determine the amount of radioactivity present in the vegetation above the soil surface. Comparison measurements of soil and overlying vegetation showed no radionuclide activity in the vegetation

exceeding background levels. FSS soil samples are therefore taken with overlying vegetation removed but with the root ball intact in accordance with approved procedures.

Sediment, groundwater and surface water samples were also included in this category. Over 100 sediment samples were obtained from shorelines, outfalls, catch basins, runoff ditches and the forebay. Twelve sediment samples were also obtained from offsite sources such as the Damariscotta River and Harpswell for background purposes. Over fifteen water samples were taken from groundwater monitoring wells, sumps, catch basins and an outfall. Five water samples were taken from offsite or unaffected sources for background purposes. In addition, the Radiological Environmental Monitoring Program has collected over 27 years of sediment, groundwater and surface water sampling data. For instance, the Annual Radiological Environmental Operating Report for 1999, submitted to the NRC on April 27, 2000, describes the automatic composite sampler located at the discharge of the forebay to monitor water discharged to the Back River. Samples were collected at least every two hours and subsequently composited for analysis. Groundwater from an on-site location was monitored quarterly. Shoreline sediment cores were collected semiannually from two locations on Bailey Point.

Multiple soil samples were taken and composited to determine the amounts and ratios of the hard-to-detect radionuclides in the most contaminated soils onsite.

Scan and fixed surveys of pavement were performed to identify potential sub-surface contamination. Two areas of soil contamination beneath pavement were documented in the HSA. One area of sub-slab leakage from the liquid waste effluent line occurred underneath the Service Building floor. The results of this soil contamination were contained in the 50.75(g) file.

### 2.3.3 Characterization Survey Design

All phases of the characterization surveys were designed to sample each structure, system and land area onsite for the presence of radioactive contamination. A heavy emphasis was placed on non-affected (non-impacted) systems, structures and areas with 2750 more surveys taken on non-affected systems, 1500 more surveys taken on non-affected surfaces and structures, and 18 survey packages devoted to non-affected areas versus 7 for affected areas. This emphasis ensured that the full nature and extent of the contamination were identified and characterized.

The initial radiological characterization survey (ICS) was organized, performed and reported in one of five "Groups" and 127 packages which are listed in Section 2.3.7. Each group is comprised of plant areas containing similar types of media, or material, and similar contamination potential. The types of media included surfaces, structures, systems and environs. The environs category included facility grounds within and outside the RA, the liquid effluent pathway, Montsweag Bay, groundwater wells and remote locations within the MY Atomic Power Plant site boundaries. The contamination potential for the media in a given group was generally categorized as affected and unaffected. Affected areas had medium to high potential for containing contamination. Unaffected areas had a low or no potential for containing contamination. The affected/unaffected designation was not intended to indicate final survey classification status, but was intended as a general descriptor of contamination potential. The methods for converting any of the characterization survey results to classification of plant areas for final site survey are described in Section 5 of this LTP.

Each group was further subdivided into survey packages that correspond to specific plant areas with similar operational history or physical location. The survey package breakdown is contained in Attachment 2B. All plant areas are included in one of the survey groups/packages. The five groups are listed below.

- Group A-Affected Surfaces and Structures
- Group B-Unaffected Surfaces and Structures
- Group C-Affected Systems
- Group D-Unaffected Systems
- Group R-Radiologically Affected or Unaffected Environs

These group designators were also used during continued characterization (CCS) for survey package identification. Non-radiological data were collected and grouped into one of the following two categories listed below. The environs hazardous material characterization surveys (ICS) included testing for PCBs, RCRA metals, semi-volatile organic compounds and volatile organic compounds.

- Group E-Hazardous Materials on Structures, Systems or Surfaces
- Group H-Hazardous Materials in Environs

Activation analysis calculations were also performed for the reactor vessel, reactor internals and the shield wall surrounding the reactor.

#### 2.3.4 Instrumentation and Minimum Detectable Concentrations (MDCs) Instrument Selection and Use

Instrument selection, use and calibration for the MY characterization surveys (ICS and CCS) were based on the assumed radionuclide mix and were performed in accordance with approved procedures. Instruments used and their MDCs are described in the applicable section.

##### a. Survey Methods

Direct measurements of structures were performed with 126 cm<sup>2</sup> gas flow proportional detectors for beta contamination. The MDC was between 500-2000 dpm/100 cm<sup>2</sup> (as compared to the screening values of 5,000-11,000 dpm/100 cm<sup>2</sup>). The detector was kept within 1 cm of the surface. Measurements of surface activity on small or restricted access areas were made using small Geiger-Mueller detectors or an array of multiple detectors for large bore systems or components. Measurement times were controlled in order to achieve the required MDCs.

Scan surveys were performed on both surfaces and land in order to detect areas of elevated activity for further investigation.

GTS Duratek performed scans (ICS) of open land areas with a 1 inch by 1 inch NaI detector or the large "drive-around" plastic scintillator. Scan speeds were controlled in order to meet the required MDCs. Audible output was used with the handheld instruments to aid the surveyor in identifying areas of elevated readings. Continuing characterization scans (CCS) were performed using a 2 inch by 2 inch detector swept in a pendulum pattern at a distance of 2 inches from the surface at a rate of 0.5 m/sec.

Samples of building materials, sediments, sludges and water were taken and analyzed using standard procedures and laboratory instruments. Smears for removable contamination were taken using standard techniques and laboratory counters. Exposure rates at one meter were measured using a NaI detector and a pressurized ion chamber. Soil samples of approximately 1000 g were cleaned to remove large debris and dried to remove moisture. Samples were counted in Maranelli beakers using GeLi detectors for gamma emitters. Samples were analyzed by off site labs for Hard-To-Detect (HTD) radionuclides.

##### b. Minimum Detectable Concentrations for Volumetric Measurements

The MDCs listed in Table 2-2 were typical values for both initial characterization (ICS) and continued characterization (CCS) samples,

which included HTD nuclides. The lower values were for gamma spec analyses. When characterization soil samples (ICS and CCS) were analyzed for HTDs, the MDCs were maintained at levels as low as practicable.

Minimum detectable concentrations (MDCs) were defined for measurements and analyses used to quantify soil and other volumetric activity. Similar instruments, procedures, and MDCs applied to continuing characterization. MDCs for volumetric soil were less than 0.01 pCi/g for gamma nuclides versus a screening value of approximately 3-4 pCi/g for a 10 mrem/yr annual dose. MDAs for Volumetric Water were less than 2,500 pCi/L for H-3. There is no water screening value.

<b>Table 2-2 Volumetric MDCs</b>		
<b>Type of Analysis</b>	<b>MDC (pCi/g)</b>	
	<b>GTS (ICS)</b>	<b>DOC/MY (CCS)</b>
Gamma Spectroscopy	0.10	0.01 - 0.1
Liquid Scintillation	2.0 to 3.0	2.5
Alpha Spectroscopy	0.10	0.01 to 1.0
Radio Chemical Analysis	* 1 - 20 pCi/g	* 1 - 20 pCi/g

\* except Ni-59

c. Structure and Surface Scan Sensitivities

GTS Duratek used a slightly different method for calculating scan sensitivities (ICS) than the method specified in NUREG-1575/NUREG-1507. This approach increased the calculated scan MDCs by a factor of approximately 2.4. The use of this alternate approach had no effect on the interpretation and use of initial characterization data (ICS). The technicians evaluated detectably elevated readings during scan surveys based on changes in count rates regardless of the estimated MDC.

GTS Duratek performed a computerized sort of the direct measurements of total beta activity obtained during the characterization survey (ICS) of unaffected areas by detector type, efficiency, local area background and use (building surfaces vs. system internals) in order to evaluate scan MDCs. The surface scan MDCs ranged from 2100 dpm/100 cm<sup>2</sup> for large



area gas flow detectors to 16,000 dpm/100 cm<sup>2</sup> for system internals surveys.

The NUREG-1575/NUREG-1507 method was used to calculate scan sensitivities in the continuing characterization work (CCS). This method yielded surface scan MDCs of 1200-16,000 dpm/100 cm<sup>2</sup> depending on the instrument and material being surveyed.

d. Open Land Area Scans

GTS technicians performed gamma scans of open land areas (ICS) using a Ludlum 44-2, 1 inch by 1 inch NaI detector, and a TSA Systems Limited large area plastic scintillator, VRM-1X. (See Table 2-3.) In accessible areas, the VRM-1X detector, a 1.5 inch thick, by 3 inch wide, by 33 inch long block of scintillator-impregnated plastic, was the detector of choice because it had the lower theoretical MDC. The relatively large surface area of the VRM-1X detector greatly improves the probability of detecting isolated areas that contain elevated levels of radioactive materials.

<b>Table 2-3</b> <b>Theoretical Scanning Sensitivities</b>	
<b>Instrument</b>	<b>Minimum Detectable Concentration/Activity</b>
Ludlum 44-2	14 pCi/g (Cs-137 source)
VRM-1X	11 pCi/g* (Distributed Co-60)
SPA-3	5 pCi/g (Cs-137 source)

\* MDC as determined by Dr. Chabot in a letter to P. Dostie dated 11/12/98

Although GTS did not perform *a priori* MDC calculations, theoretical minimum detectable concentrations or minimum detectable activities for scans (ICS) performed with a vehicle-mounted VRM-1X detector, traveling at less than 5 mph, were calculated for several geometries based on empirical data and numerical integrations following land surveys.

These data were examined by Dr. Chabot on 11/12/98 and found to be accurate within a factor of 2 to 4.

The SPA-3 detectors (2 inch by 2 inch NaI) were used for land area scans during continuing characterization (CCS) with scan MDCs of approximately 5 pCi/g (Cs-137 source). This nominal MDC value of 5 pCi/g was based on a background of 10,000 c/m, an index of sensitivity

(d') of 1.38, a surveyor efficiency factor of 0.707, and a conversion factor of 1200 c/m per microR/hr, as stated in the manufacturer's literature. The exposure rate of soil for 5 pCi/g was determined by Microshield and was the same value of 1.3 microR/hr, as given in Section 6.7.2.1 of NUREG-1575.

e. Instrument Calibrations

Analytical and field instruments for both ICS and CCS were calibrated using National Institute of Standards and Technology traceable sources representative of the assumed radionuclide mix at the MY site. Instruments were calibrated at the MY site and, for GTS, at the GTS Duratek Central Calibration Facility in Oak Ridge, Tennessee or by vendors in accordance with the GTS Duratek Quality Assurance Project Plan for Site Characterization (ICS). Approved procedures were employed to specify on-site instrumentation calibration requirements for continuing characterization (CCS). The average energy of the beta particles in the MY radionuclide mixture was calculated. Based on the calculated average source beta energy of 0.088 Mev, Tc-99 (ave. beta energy of 0.085 Mev) was chosen for calibration. All of the alpha emitters have similar energies and Am-241 was chosen for the alpha calibration source. Tc-99 and Am-241 sources were used for calibrating gas flow proportional instruments used to perform surface scans and direct measurements. Cs-137 sources were used to calibrate exposure rate and soil scan instruments. The calibration program ensured that equipment was of the proper type, range, accuracy and precision to provide data to support the MY site characterization activities. The response of exposure rate and soil scan instruments to Co-60 was also determined during continued characterization (CCS) in order to detect discrete Co-60 particles.

### 2.3.5 Quality Assurance

Quality Assurance plans were developed for characterization work (ICS and CCS). The elements of these plans were very similar. Differences between plans are discussed below.

The GTS Quality Assurance Project Plan (QAPP) described the quality assurance requirements for the initial site characterization survey (ICS). The QAPP included applicable criteria from the GTS Duratek Quality Management System Manual specific to the MY project. The plan addressed sample collection, field survey measurements, sample analysis, data analysis/verification, and document control.

Continuing characterization (CCS) was performed using an approved CCS Quality Control procedure which addressed the quality elements for these surveys. The

procedure covered the requirements and frequency for replicate measurements, sample recounts, split samples, instrument use and control, sample custody, data verification/control, document control and investigation of unusual results.

a. Quality Control Samples and Measurements

For each laboratory instrument used during both initial characterization (ICS) and continuing characterization (CCS), laboratory personnel kept daily quality control charts, a log of samples analyzed to provide traceability for each step of the analysis, and a maintenance log. Daily quality control checks were compared to specified tolerances. Control charts were developed at the time of initial calibration using a statistical analysis of repetitive measurements. Laboratory personnel maintained control charts for energy, full width at half maximum (FWHM), and efficiency for each gamma spectroscopy system and performed trend analysis daily. Routine background and blank counts demonstrated that the detector or cave had not become contaminated and confirmed sample detection levels. Daily checks were also performed on the analytical balance which was used to weigh the samples. Instruments failing the daily checks were removed from service until repaired.

The GTS Sample Analysis and Data Management Plan (ICS) identified required quality control samples and measurements. In addition to the daily instrument quality control described above, laboratory personnel used quality control samples and measurements to verify system performance and data reproducibility.

The following on site QC analyses were performed and compared by GTS (ICS) using criteria in US NRC Inspection Procedure 84750:

- 10% of all samples were analyzed twice in the on-site laboratory (duplicate analysis)
- 10% of all samples were split and analyzed as two separate samples

Quality control at the contract (off site) laboratories (ICS) also included daily instrument checks and quality control samples that were analyzed during analysis of a batch of samples. Quality control samples and analyses for a batch of 20 (or fewer) samples analyzed by the contract laboratory included: a blank sample, a matrix spike sample (laboratory control sample, LCS), and a homogenized split sample. Laboratory control samples and analyses performed by the off-site laboratory were required to meet a relative percent difference (RPD) of 20% in accordance with the laboratory's internal procedures.

An approved CCS Quality Control procedure for the sample quality control criteria was developed. This procedure covered instrument daily checks, split or spiked sample requirements and acceptability criteria. Five percent of all survey units were chosen for repeat surveys with 10% of scans and fixed point measurements being replicated. Agreement for replicates was considered to be values within  $\pm 2$  standard deviations. Instruments not passing the daily source check requirements were tagged "Do Not Use" and were removed from service until repaired. Data not meeting the replicate count criteria were removed from the data base until evaluated by an FSS specialist or engineer.

Duke Engineering & Services Environmental Laboratory performed laboratory analyses (CCS) under the requirements of DESEL Manual 100, "Laboratory Quality Assurance Plan."

The methods used by the off site laboratory for analysis of hazardous materials (ICS) were based on the EPA method for solid waste analysis SW-846. Specific quality control samples, analysis, and acceptance criteria are specified in the analysis methods.

GTS personnel implemented the QAPP (ICS) through:

- Scheduled audits and surveillances by on-site and off-site personnel
- Development of training matrices and training of personnel
- Development of records flow schedules
- Development of document control criteria
- Completion of readiness review checklists

Self-assessments for CCS were implemented in accordance with approved Radiation Protection Performance Assessment Program procedures. Training and qualification of survey personnel were assessed in accordance with the approved procedure for Selection, Training and Qualification of Radiation Protection Personnel. Records Control was maintained in accordance with approved procedures for QA Records Management.

b. Audits and Surveillances

MY provided oversight of survey and sample activities to determine whether the overall characterization plan was implemented as designed. External audits of project activities included assessments by MY personnel

and subcontractors. These included an audit of the GTS Duratek facility (ICS) in Kingston, TN and project-specific audits based on the Quality Assurance Program Plan and other project plans. These audits did not identify any project-specific nonconformances. In addition, MY personnel and their contractors performed surveillances on daily project operations. Characterization personnel identified, tracked, and corrected concerns generated by these surveillances.

MY Radiological Engineering and GTS Duratek corporate and Field Services personnel (ICS) performed internal audits of the project. Also, at the request of MY, GTS Duratek appointed an on-site surveillance technician. This inspector, trained on quality assurance procedures, performed daily surveillances on project activities. Characterization personnel (ICS) tracked and corrected nonconformances identified by these surveillances according to approved procedures.

During continued characterization (CCS), audits and self assessments were performed on the characterization activities. The results of the findings were entered into the trend data base and tracked to resolution in accordance with the approved procedure for the Corrective Action Program.

#### 2.3.6 Data Quality Objectives

Initial site characterization (ICS) was planned prior to the issuance of NUREG-1575. However, a retrospective look at site characterization revealed that Data Quality Objectives (DQOs) 1, 2, 3 and 4 were addressed by GTS Duratek. The characterization plan identified the problem, the decision method, the resources, the team, the decision makers, the sample requirements, the instrumentation and MDCs, the expected nuclides, the survey areas and basic data analysis. While the use of a formal DQO process may have resulted in a more efficient characterization process, the resulting data have been shown to be sufficient to meet the objectives listed in Section 1.0 and are therefore acceptable.

The DQO process was used during continuing characterization (CCS) to meet the objectives outlined in Section 2.1. Contamination boundaries, radionuclide profiles, data standard deviations and projected sample sizes were determined during continuing characterization.

Data Quality Objectives 5, 6 and 7 are addressed in LTP Section 5, Final Status Survey, and Section 6, Compliance with the Radiological Criteria. In particular for DQO 5, the parameter of interest is specified as the mean of the residual contamination level in a survey unit, the action levels include the DCGL and the investigation levels, and the decision rule is described for the determination to

release a survey unit. For DQO 6, the limitations of decision errors are addressed by specifying the respective probabilities of making a Type I and Type II decision error, the lower boundary of the grey region (LBGR) and the minimum value for relative shift. For DQO 7, the survey design for collecting data is optimized by using exposure pathway modeling to develop some site-specific DCGLs, adjusting the LBGR to obtain the optimum relative shift, evaluating survey instrumentation and measurement techniques and selecting appropriate actions following the exceedance of investigation levels.

### 2.3.7 Survey Findings And Results

The results of the initial characterization surveys (ICS) are reported by survey group and package number as identified below.<sup>3</sup> Site and Survey Area maps are provided in this section of the LTP to graphically depict the boundaries of each area. These maps are not drawn to scale but are sufficient to show the presence of areas of high contamination.

The only land, structures, and systems that remain within the control of the 10 CFR 50 License are those where the ISFSI is located and an adjacent parcel of land. This information is maintained to support decommissioning of the remaining areas associated with the ISFSI following the removal of spent fuel and GTCC waste from the site.

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<sup>3</sup> Additional survey packages were developed (and are discussed in this section) as necessary to support data collection for continued characterization. These later packages are not listed here in Section 2.3.7.

<b>PACKAGE NUMBER</b>	<b>GROUP "A" Affected Structures and Surfaces Survey Packages</b>
<b>A0100</b>	<b>Containment Building - Elevation -2 ft.</b>
<b>A0200</b>	<b>Containment Building - Elevation -20 ft.</b>
<b>A0300</b>	<b>Containment Building - Elevation 46 ft</b>
<b>A0400</b>	<b>Fuel Building - Elevation 21 ft.</b>
<b>A0500</b>	<b>Demineralized Water Storage Tank TK-21 - Elevation 21 ft.</b>
<b>A0600</b>	<b>Primary Auxiliary Building - Elevation 11 ft.</b>
<b>A0700</b>	<b>Primary Auxiliary Building - Elevation 21 ft.</b>
<b>A0800</b>	<b>Primary Auxiliary Building - Elevation 36 ft.</b>
<b>A0900</b>	<b>Service Building Hot Side - Elevation 21 ft.</b>
<b>A1100</b>	<b>Low Level Waste Storage Building - Elevation 21 ft.</b>
<b>A1200</b>	<b>RCA Building - Elevation 21 ft.</b>
<b>A1300</b>	<b>Equipment Hatch Area - Elevation 21 ft.</b>
<b>A1400</b>	<b>Personnel Hatch Area - Elevation 21 ft.</b>
<b>A1500</b>	<b>Mechanical Penetration Room - Elevation 21 ft.</b>
<b>A1600</b>	<b>Electrical Penetration Room - All Elevations</b>
<b>A1700</b>	<b>Containment Spray Building - All Elevations</b>
<b>A1800</b>	<b>Auxiliary Feed Pump Room - Elevation 21 ft.</b>
<b>A1900</b>	<b>HV-9 Area - Elevation 21 ft.</b>
<b>A2100</b>	<b>Refueling Water Storage Tank (RWST) TK-4 - Elevation 21 ft.</b>
<b>A2200</b>	<b>Borated Water Storage Tank (BWST) - Elevation 21 ft.</b>
<b>A2300</b>	<b>Processed (Primary) Water Storage Tank (PWST) - Elevation 21 ft.</b>
<b>A2400</b>	<b>Test Tanks 14A/14B -Elevation 21 ft.</b>
<b>A9900</b>	<b>Concrete core contamination profile sampling</b>
<b>A9901</b>	<b>Activation analysis core sampling</b>
<b>A9902</b>	<b>Activation analysis core sampling</b>

<b>PACKAGE NUMBER</b>	<b>GROUP "B" Unaffected Structures and Surfaces Survey Packages</b>
<b>B0100</b>	<b>Turbine Deck - Elevation 61 ft.</b>
<b>B0200</b>	<b>Old Control Room - Elevation 21 ft.</b>
<b>B0300</b>	<b>Motor Control Center (MCC)/Battery Room - Elevation 62 ft.</b>
<b>B0400</b>	<b>Fire Pump House - Elevation 1</b>
<b>B0500</b>	<b>Condenser Bay - Elevation 21 ft.</b>
<b>B0600</b>	<b>Condenser Bay - Elevation 39 ft.</b>
<b>B0700</b>	<b>Service Building Cold Side - Elevation 21 ft.</b>
<b>B0800</b>	<b>Fuel Oil Building - Elevation 21 ft.</b>
<b>B0900</b>	<b>Emergency Diesel Generators - Elevation 21 ft.</b>
<b>B1000</b>	<b>Auxiliary Boiler Room - Elevation 21 ft.</b>
<b>B1100</b>	<b>Recirculating Water Pump House - All Elevations</b>
<b>B1200</b>	<b>Administration Center - Elevation 21 ft.</b>
<b>B1300</b>	<b>WART Building - All Elevations</b>
<b>B1400</b>	<b>Visitor and Information Center - Elevation 1</b>
<b>B1500</b>	<b>Warehouse 2 - Elevation 1</b>
<b>B1600</b>	<b>Training Annex Building - Elevation 1</b>
<b>B1700</b>	<b>Staff Building - All Elevations</b>
<b>B1800</b>	<b>Spare Generator Building - Elevation 1</b>
<b>B1900</b>	<b>Environmental Services Building - All Elevations</b>
<b>B2000</b>	<b>Bailey Barn - Elevation 1</b>
<b>B2100</b>	<b>Lube Oil Storage Room - Turbine Building Elevation 21 ft.</b>
<b>B2200</b>	<b>Cold Machine Shop - Turbine Building Elevation 21 ft.</b>
<b>B2300</b>	<b>Cable Vault Room - Turbine Building Elevation 39 ft.</b>
<b>B2400</b>	<b>Staff Building Tunnel - Staff Building to Turbine Building Elevation 21 ft.</b>
<b>B9800</b>	<b>Structural Background Survey</b>



<b>PACKAGE NUMBER</b>	<b>GROUP "C" Affected Plant Systems Survey Packages</b>
<b>C0100</b>	<b>Primary and Post Accident Sampling System</b>
<b>C0200</b>	<b>Waste Solidification System</b>
<b>C0300</b>	<b>Containment Spray System</b>
<b>C0400</b>	<b>Emergency Core Cooling System</b>
<b>C0500</b>	<b>Residual Heat Removal System</b>
<b>C0600</b>	<b>Primary Vents and Drains</b>
<b>C0700</b>	<b>Fuel Pool Cooling System</b>
<b>C0800</b>	<b>Waste Gas Disposal System</b>
<b>C0900</b>	<b>Pressurizer and Pressurizer Relief System</b>
<b>C1100</b>	<b>Reactor Coolant System</b>
<b>C1200</b>	<b>Boron Recovery System</b>
<b>C1300</b>	<b>Chemical and Volume Control System</b>
<b>C1400</b>	<b>Liquid Waste Disposal System</b>
<b>C1500</b>	<b>Primary Auxillary Building Drains</b>
<b>C1600</b>	<b>Primary Auxillary Building Ventilation</b>
<b>C1800</b>	<b>Containment Ventilation System</b>
<b>C1900</b>	<b>Steam Generators</b>

<b>PACKAGE NUMBER</b>	<b>GROUP "D" Unaffected Plant Systems Survey Packages</b>
<b>D0100</b>	<b>Condensate System</b>
<b>D0200</b>	<b>Water Treatment Plant Systems</b>
<b>D0300</b>	<b>Potable Water System</b>
<b>D0400</b>	<b>Sanitary Sewer System</b>
<b>D0500</b>	<b>Circulating Water and Screen Wash System</b>
<b>D0600</b>	<b>Service Water System</b>
<b>D0700</b>	<b>Fire Protection System</b>
<b>D0800</b>	<b>Lube Oil System</b>
<b>D0900</b>	<b>Compressed Air System</b>
<b>D1000</b>	<b>Auxiliary Boiler System</b>
<b>D1100</b>	<b>Steam Generator System</b>
<b>D1200</b>	<b>Main and Reheat Steam System</b>
<b>D1300</b>	<b>Auxiliary Steam System</b>
<b>D1400</b>	<b>Main Turbine and Turbine Control System</b>
<b>D1500</b>	<b>Steam Dump and Turbine Bypass System</b>
<b>D1600</b>	<b>Main Feedwater System</b>
<b>D1700</b>	<b>Emergency/Auxiliary Feedwater System</b>
<b>D1800</b>	<b>Heater Drain and Extraction Steam System</b>
<b>D1900</b>	<b>Component Cooling Water System</b>
<b>D2000</b>	<b>Vacuum Priming and Air Removal System</b>
<b>D2100</b>	<b>Amertap System</b>
<b>D2200</b>	<b>Secondary Plant Sealing System</b>
<b>D2300</b>	<b>Auxiliary Diesel Generator</b>
<b>D2400</b>	<b>Secondary Sample and Chemical Addition System</b>
<b>D2500</b>	<b>High Pressure Drains</b>
<b>D2600</b>	<b>Environmental Services Laboratory Systems</b>
<b>D2700</b>	<b>Administration Building HVAC System</b>
<b>D2800</b>	<b>Information Building HVAC System</b>
<b>D2900</b>	<b>Turbine Building Ventilation System</b>
<b>D3000</b>	<b>Staff Building HVAC System</b>
<b>D3100</b>	<b>Service Building HVAC System</b>
<b>D3200</b>	<b>Hydrogen and Nitrogen System</b>
<b>D3300</b>	<b>Turbine Building Sumps and Drains</b>

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PACKAGE NUMBER	GROUP "D" Unaffected Plant Systems Survey Packages
D3400	Low Level Radioactive Waste Storage Facility

<b>PACKAGE NUMBER</b>	<b>GROUP "R" Environs Affected and Unaffected Survey Packages</b>
<b>AFFECTED</b>	
<b>R0100</b>	<b>RCA portion (West Side) of Protected Area Yard</b>
<b>R0200</b>	<b>Balance of Protected Area (East Side)</b>
<b>R0300</b>	<b>Roof and Yard Drains #006, #007 and #008</b>
<b>R0400</b>	<b>Forebay Area Shorelines</b>
<b>R0500</b>	<b>Bailey Point</b>
<b>R0600</b>	<b>Ball Field</b>
<b>R0700</b>	<b>Construction Debris Landfill</b>
<b>UNAFFECTED</b>	
<b>R0800</b>	<b>Administration and Parking Areas</b>
<b>R0900</b>	<b>Balance of Plant Areas</b>
<b>R1000</b>	<b>Foxbird Island</b>
<b>R1100</b>	<b>Roof and Yard Drains #005, #009-12, #017 and N-12</b>
<b>R1200</b>	<b>Low Level Radioactive Waste (LLRW) Storage Building Yard</b>
<b>R1300</b>	<b>Dry Cask Storage Area</b>
<b>R1400</b>	<b>Westport, Montsweag Bay, Bailey Point Cove and Plant Area Shorelines</b>
<b>R1500</b>	<b>Ash Road Area Rubble Piles</b>
<b>R1600</b>	<b>Owner Controlled Area West of Bailey Cove</b>
<b>R1700</b>	<b>Owner Controlled Area North of Old Ferry Road</b>
<b>R1800</b>	<b>Bailey House Area</b>
<b>R1900</b>	<b>Bailey Cove</b>
<b>R2000</b>	<b>Diffusers</b>
<b>R2100</b>	<b>Maintenance Yard (Stockyard)</b>
<b>R2200</b>	<b>Background</b>
<b>R2300</b>	<b>SFPI Substation Slab</b>
<b>R2400</b>	<b>IT Duplicate Samples</b>
<b>R2500</b>	<b>Driveover Elevated Areas</b>
<b>R2501</b>	<b>Follow-up sampling at Elevated Soil Sample Locations (south of Refueling Water Storage Tank and Contractor Parking Lot)</b>
<b>R2800</b>	<b>10 CFR 61 Analysis Sampling</b>

Hazardous and chemical material surveys (ICS) were performed on the materials, systems and areas as specified in the tables for Group E and Group H below. The data for these groups are presented in the Summary of Site Characterization Data section which follows.

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<b>PACKAGE NUMBER</b>	<b>GROUP "E" Plant Surfaces, Structures and Systems Hazardous Material Survey Packages</b>
<b>E0100</b>	<b>Protected Area Paint</b>
<b>E0200</b>	<b>Plant Electric Components</b>
<b>E0300</b>	<b>Transformer Oils</b>
<b>E0400</b>	<b>Plant Pump Oils</b>
<b>E0500</b>	<b>Various Plant Fluids</b>
<b>E0600</b>	<b>Component Cooling Water</b>
<b>E0700</b>	<b>Brass, Bronze and Cadmium Plated Components</b>
<b>E0800</b>	<b>Plant Batteries</b>
<b>E0900</b>	<b>Mercury Components</b>
<b>E1000</b>	<b>Asbestos Insulation and Other Materials</b>
<b>E1100</b>	<b>Asbestos Containing Components</b>
<b>E1200</b>	<b>Lead Shielding</b>
<b>E1300</b>	<b>Paint Outside Protected Area</b>

<b>PACKAGE NUMBER</b>	<b>GROUP "H" Environs Areas Hazardous Material Survey Packages</b>
<b>H0100</b>	<b>Oil and Hazardous Material Transfer and Handling Areas (4)</b>
<b>H0200</b>	<b>Diesel Oil Tank Loading Area</b>
<b>H0300</b>	<b>Main, North, Spare and Shutdown Transformers</b>
<b>H0400</b>	<b>Roof and Yard Drains #006, #007 and #008</b>
<b>H0500</b>	<b>Solid Waste Storage Area</b>
<b>H0600</b>	<b>Primary and Secondary Side Waste Storage Building Yard Areas</b>
<b>H0700</b>	<b>Drumming/Decontamination Waste Accumulation Area</b>
<b>H0800</b>	<b>Diffuser Forebay</b>
<b>H0900</b>	<b>Reactor Water Storage Tank Area</b>
<b>H1000</b>	<b>Groundwater Monitoring Wells B-201 through 206, MW-100, BK-1</b>
<b>H1100</b>	<b>Warehouse Yards</b>
<b>H1200</b>	<b>Fire Pond and Yard Area</b>
<b>H1300</b>	<b>Construction Debris Landfill</b>
<b>H1400</b>	<b>Bailey Point</b>
<b>H1500</b>	<b>Administration and Parking Areas</b>
<b>H1600</b>	<b>Roof and Yard Drains #005, #009-12 and N-12</b>
<b>H1700</b>	<b>Surface Flow Drain #005</b>
<b>H1800</b>	<b>Balance of Plant Area</b>
<b>H1900</b>	<b>Foxbird Island</b>
<b>H2000</b>	<b>Low Level Waste Storage Yard</b>
<b>H2100</b>	<b>Dry Cask Area</b>
<b>H2200</b>	<b>Environmental Services Laboratory</b>
<b>H2300</b>	<b>Switchyards</b>
<b>H2400</b>	<b>Areas Outside Plant Impact</b>

## 2.4 Summary of Initial Characterization Survey (ICS) Results

The operational history and the range of contamination determined during initial site characterization (ICS) are summarized in this section for the survey groups indicated above. More detailed data including mean, maximum, and standard deviation are presented by survey package in Attachment 2B.

### 2.4.1 Group A "Affected Structures and Surfaces"

Group A included buildings and surfaces within the RA including levels of the Reactor Containment, Fuel, and Primary Auxiliary Buildings, as well as tanks containing radioactive liquids, electrical/mechanical penetration areas and concrete surface samples. Areas of known contamination with very high dose rates were sampled less than areas with more moderate dose rates in order to maintain the exposure to surveyors ALARA. Survey data were taken from posted areas which included High Radiation Areas, Radiation Areas, Radioactive Material Storage Areas and Contaminated Areas. These areas included the reactor coolant system and waste processing equipment and were among the most highly contaminated areas on site. However, several locations within this group contained no radioactive systems, components and structures or were found to be below station limits for posting as contaminated (viz., DWST, PWST, electrical and mechanical penetration areas and the auxiliary feed pump room).

Maximum total surface activities ranged from greater than 100,000 dpm/100 cm<sup>2</sup> in the RCA Building, Containment Building (CTMT), and Spray Buildings to less than 1000 dpm/100 cm<sup>2</sup> in auxiliary support areas (e.g., electrical/mechanical penetrations). Maximum removable beta activities ranged from greater than 128,000 dpm/100 cm<sup>2</sup> in the CTMT to less than MDA in auxiliary support areas. No removable alpha sample activities were above the MDA values which indicated little or no transuranic (TRU) surface contamination. Maximum net exposure rates reported in Attachment 2B ranged from about 4,000  $\mu$ R/hr in the Primary Auxiliary Building (PAB) to around 5  $\mu$ R/hr in the mechanical penetration area. Operational surveys reported containment exposure rates ranging from 1 mrem/hr to over 1000 mrem/hr.

Group A results combined with the operational survey data and knowledge of process provided the information needed to target those structures within the RA requiring remediation, establish radionuclide profiles and provide estimated radioactive waste volumes.

### 2.4.2 Group B "Unaffected Structures and Surfaces"

Group B was comprised of buildings and surfaces located outside the RA including the Turbine Hall, sections of the Service Building, the Control Room, office spaces and various out buildings such as the Fire Pond Pump House, the warehouse, and the Bailey House/Barn. With the exception of a few closed secondary systems and

a few locations in the Turbine Hall, Service Building and warehouse, none of these buildings contained or stored radioactive material during plant operation and are therefore some of the lowest activity areas on site. Sealed sources for instrument calibration were stored at the Bailey House environmental laboratory.

The crane bay and turbine deck in the Turbine Hall were used for RCP motor refurbishment. The 1990 steam generator tube leak affected steam and feedwater components in the Turbine Hall. The auxiliary boilers were known to be internally contaminated. Some areas within the Service Building such as the old decon shower and primary chemistry lab sample hoods were also known to be slightly contaminated. The warehouse was used as a shipment and receipt point for small quantities of packaged radioactive material. There was no evidence of leakage detected at the warehouse from packages shipped or received.

Maximum total surface activities ranged from a high values of 3700 dpm/100 cm<sup>2</sup> and 8600 dpm/100 cm<sup>2</sup> in the Turbine Building (certain floor areas) to lows of <1000 dpm/100 cm<sup>2</sup> in outlying areas, such as the cable vault. The Ball Field Dugout indicated 700 dpm/100 cm<sup>2</sup>, which was later identified by the State of Maine as Co-60. Maximum removable beta activities ranged from 200 dpm/100 cm<sup>2</sup> in the Turbine Building to less than MDA in other areas. No areas had plant related alpha activity above the MDA level. Maximum exposure rates ranged from 26  $\mu$ R/hr in the Service Building to 2  $\mu$ R/hr in the Turbine Building. Tritium was detected slightly above MDA in several water-containing systems. High beta readings in the Bailey House were confirmed to be NORM from the granite foundation blocks.

Group B surveys verified that most of the Turbine Hall was free of residual radioactivity. Continuing characterization surveys (CCS) established the extent and limits of radioactivity in the areas in which it was found.

#### 2.4.3 Group C "Affected Plant Systems"

This group was comprised of the radioactive systems such as the RCS, CVCS, ECCS, liquid and solid waste, containment ventilation and primary vents and drains. The survey packages in this group consisted of systems and components that were removed and disposed of as radioactive waste during decommissioning and, therefore, did not require characterization to support Final Status Survey (FSS). These are the highest radioactively contaminated systems at MY.

Total surface activities were not measured on these systems' internals, as their activity levels were too high. Instead, 15 cm and 1 meter external exposure rate measurements were taken at four quadrants from system locations, to support dose to curie calculations, for waste shipping purposes. Internal system surfaces of the steam generators were found to be contaminated up to 500,000 dpm/100 cm<sup>2</sup> removable beta activity. Alpha activity was present at as much as 35 dpm/100 cm<sup>2</sup> in the CVCS indicating possible TRU contamination. Exposure rates in these



areas ranged from a low of 13  $\mu\text{R/hr}$  in the Waste Solidification system to more than 16,000,000  $\mu\text{R/hr}$  in the Spent Fuel Cooling and Refueling system.

Group C results verified the extent of contamination in primary systems and provided data needed to support the Radiation Protection Program during component removal in addition to providing information needed for waste classification.

#### 2.4.4 Group D "Unaffected Plant Systems" Including the Sewage Treatment System

This group consisted of secondary side systems that were designed to remain non-contaminated. Examples of these systems were main steam, feedwater, compressed air and potable water. However, certain parts of the secondary side systems contained minor levels of contamination. The auxiliary condensate system was known to be slightly contaminated due to aux boiler problems early in plant life. Turbine Hall sumps were known to be slightly contaminated due to reactor coolant pump motor refurbishment activities taking place in the Turbine Hall. Steam and feedwater systems were potentially impacted by the 1990 steam generator tube leak. The Service Water system was impacted by liquid effluents from the Test Tanks. Several of the systems crossed over to the RA, where elevated readings were detected in/on the systems but were later attributed to NORM interference in the analyses. Group D systems were generally the lowest in activity of all those surveyed.

Until the early 1980s when they were disconnected, hot side shower drains and toilets were directed to the sewage treatment plant. Initial characterization surveys (ICS) showed elevated readings in one hotside shower drain. In the two years following shutdown, routine chemistry analyses of both the on site holdup tank and the municipal treatment facility have shown no plant-derived radionuclides. Radionuclides have been detected in the sewage plant as a result of employees receiving medical isotope therapy.

Survey results from Group D established the limit and extent of residual activity in systems expected to be clean and provided information to properly control the systems as well as classify the waste during decommissioning. Some of the systems in Group D had elevated readings indicating the possible presence of plant derived radioactive material. Further measurements were made on these systems as part of the continuing characterization (CCS) plan to properly evaluate the level and extent of contamination. These measurements support release and/or disposal determinations.

#### 2.4.5 Group R "Environs Affected and Unaffected"

The group was broken down into 7 affected and 18 unaffected areas. Environs sampling covered all areas of the 820 acre site (740 acres original site + purchased

buffer properties). Fifteen of the sample areas showed no detectable plant derived radioactivity. Ten of the areas (R0100, R0200, R0300, R0400, R1000, R2000 and R2300 within the protected area and R0500, R0900 and R1300 outside the protected area but on Bailey Point) had elevated readings requiring further evaluation and sampling.

Asphalt, sub-asphalt soil and uncovered soil to the South and West of Containment, Spray, Fuel and RCA Storage Buildings were known to be contaminated by system leaks and radioactive waste container storage. Excavated soil and asphalt from the RA were temporarily placed on Bailey Point and later returned to the RA. Silt from condenser cooling water intakes was removed and spread on site land located to the north and west of the 345 kV electrical switch yard. Plant-derived radionuclides had been detected in estuary sediments as a result of permitted liquid releases by environmental samples (REMP reports) taken at various times during plant operation. Minor contamination was located near storm drains adjacent to the RA. Contamination levels ranged from 1pCi/g to 11 pCi/g for Co-60 and 1pCi/g to 156 pCi/g for Cs-137 in the areas of known soil contamination from old leaks/spills (R0100).

Marine sediment samples were obtained from shorelines, outfalls of catch basins, runoff ditches and the forebay. In addition, the Radiological Environmental Monitoring Program had collected over 27 years of sediment sampling data. Shoreline sediment cores were collected semiannually from two locations off Foxbird Island. Additional sampling of off-site marine sediments was conducted pursuant to an agreement between Maine Yankee and Friends of the Coast (FERC Offer of Settlement dated December 31, 1998.)

Survey packages with indications of potentially elevated activity levels (R0500, R0600, R0700, R0800, R1000, R1300, R1600 and R1800) were combined into an investigation package designated R2500. The highest levels of activity were detected on Bailey Point from the investigation package R2500 (up to 34,000 pCi/g of Co-60) and the activity was remediated during sampling. Follow up samples taken in three areas after remediation of detected activity were documented in package R2501.

Three areas (R1500, R1600, R1700) were classified as non-impacted based on operational data, the Historical Site Assessment and the initial characterization (ICS) results.

Group R surveys determined which land areas were non-impacted and which were impacted. This group also provided the information necessary to project waste volumes from contaminated soils.

#### 2.4.6 Ventilation Ducts and Drains

Results for the biased sampling of building vents and drains can be found within the survey data for Groups C, D and R. Ventilation ducts and system drains were sampled as the most likely collection point for system contamination. This biased sampling provided a high level of assurance that contaminated systems were located, identified and, when found within secondary side buildings, marked to provide the necessary level of control over radioactive material.

Affected System Vents and Drains (C0600, C1500, C1600 and C1800) showed mean removable contamination values ranging from 53 to 51,000 dpm/100 cm<sup>2</sup> and maximum values from 6000 to 140,000 dpm/100 cm<sup>2</sup>.

Unaffected System Vents and Drains (D1800, D2000, D2500, D2700, D2800, D2900, D3000, D3100 and D3300) had two systems positively identify residual radioactivity. The Service Building HVAC (D3100) had significant activity above the MDA which was due to the hot side ventilation sources going to the Service Building ventilation duct work. D3000 Turbine Building Sumps and Drains had two (2) sumps test positive for plant derived nuclides (up to 1.7pCi/g Co-60). The Sump Oil Collection Tanks (TK-91) also test positive (1.1 pCi/g Co-60). There were four (4) other systems (D1800 - Heater Drain Extraction Steam, D2700 - Admin Building HVAC, D2900- Turbine Building Ventilation, and D3000 - Staff Building HVAC) with elevated activity. However, the elevated readings were likely due to radon daughter activity. The High Pressure Drains showed tritium activity at levels just above MDA. Tritium in these areas have been attributed to NORM interference in the analyses. These systems and components were removed as part of the decommissioning of the Maine Yankee Nuclear Plant.

Survey results from this group established the limit and extent of residual radioactivity in systems and provided necessary information for properly controlling material and for proper classification of waste during decommissioning.

#### 2.4.7 Buried and Embedded Piping

A review of prints and drawings was performed during CCS to determine the amount of buried and embedded pipe. MY has a limited amount of piping actually embedded in concrete. Total embedded piping included approximately 800 feet of primary and secondary component cooling water pipes. Based on inventory estimates made in 2002, the total embedded piping that remains on site is approximately 940 linear feet, representing slightly over 150 m<sup>2</sup>. A detailed listing of the embedded piping inventory is provided in Attachment 6-7.

Component cooling piping showed maximum activity up to 22,000 dpm/100 cm<sup>2</sup> and was removed during demolition activities. Small segments of refueling cavity and spent fuel pool skimmer piping (approximately 175 feet) were embedded within the walls of the two pools. The skimmer piping was known to be

contaminated and activity levels could be as high as 20,000 to 180,000 dpm/100 cm<sup>2</sup> removable beta contamination based on data obtained from spent fuel pool cooling (C0700) and RHR (C0500) survey packages. This piping was removed.

Circulating water and service water pipes are buried cast concrete pipes rather than embedded pipes. Eighteen direct measurements above MDC were identified in the circulating water pipes. Service water discharge piping receives the liquid effluent overboard pipe with approximately a 3 foot embedded section and showed maximum activity levels of 3100 dpm dpm/100 cm<sup>2</sup> of removable beta contamination. Mean values were less than MDA.

Embedded piping above the 17 foot elevation was removed. Piping below 17 feet was either removed during demolition or properly evaluated to ensure compliance with the enhanced state standards of 10 mrem/yr for all pathways including not more than 4 mrem/yr from groundwater sources of drinking water. Maine Yankee produced an informational set of site drawings showing the "as left" condition after decommissioning. These drawings identify the remaining buried or embedded pipe, conduit, building penetrations, cable vaults, and duct banks. This set of drawings was used to plan FSS surveys.

The following describes the principal sections of buried and embedded piping which remains following decommissioning of the Maine Yankee Nuclear Plant and which was decontaminated as necessary and subjected to FSS.

- a. Containment Spray Piping and CS Valves-approximately 68 ft. (C0300): During plant operation, the system was filled with reactor coolant water. Initial site characterization surveys (ICS) identified this as a contaminated system. Gamma isotopic samples collected from the system identified the presence of plant-derived nuclides (Co-60 and Cs-137). The portion of the system that remains following demolition of above grade structures is embedded in the concrete foundation of the Containment Building. Two valves from the containment spray system were also encased in concrete. Levels up to 40,000 dpm/100 cm<sup>2</sup> were detected in the spray system (C0300) during ICS. Higher levels of contamination were found in subsequent surveys. This 16 inch embedded piping makes up a surface area of 26.5 m<sup>2</sup>.
- b. Containment Foundation Drains-approximately 378 feet.(C2000)<sup>4</sup>: The foundation drain system was used to transfer groundwater from around the Containment Building foundation to lower the hydrostatic pressure on the foundation. The system consisted of four partially embedded transfer pipes

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<sup>4</sup> As noted in Section 2.3.7, additional survey packages were developed for data collection during continued characterization (i.e., not part of ICS) and, thus, are not listed in Section 2.3.7. Survey Packages C2000, D3500, and D3700 are examples of packages developed for CCS and/or for FSS using the same numbering system as was used for ICS.

that drained to the foundation sump. The system had a high potential for residual contamination. The drain system was wholly contained within the RA and was subjected to liquid spills in the soil around the Containment Building. The system was not surveyed during initial site characterization (ICS); however, the sump water was sampled periodically. Tritium was the only nuclide identified in the sump water at levels exceeding natural background. A water sample was submitted for HTD analysis during CCS and only tritium was detected. See Section 2.4.12. No removable surface contamination or direct surface measurements have been made. This combination of 2 inch and 6 inch embedded piping makes a surface area of 30.2 m<sup>2</sup>.

- c. Sanitary Waste (D0400): A portion of the sanitary waste piping was buried beneath the Turbine Hall floor slab and extended to the sewage treatment plant. At one time early in the plant's operation, the pipe transferred waste from sanitary facilities located within the RA. The original discharge point for treated sanitary waste was into the circulating water inlet bay. In the mid-1980s, the sanitary system was connected to the town of Wiscasset sewage system. The sanitary system, including the discharge to the town of Wiscasset, was sampled periodically. Radionuclides detected were limited to medical isotopes which were short lived. Of 37 fixed point surface measurements of the system taken during ICS, two were in the RA, and both indicated elevated activity of up to 5700 dpm/100 cm<sup>2</sup>. Both of these samples were from a disused drain in the system that was removed during dismantlement. No removable contamination was identified in the system. Gamma isotopic samples from the system did not indicate the presence of plant-derived radionuclides.
- d. Circulating Water System-approximately 1600 feet (D0500): The circulating water system consisted of 4 buried concrete inlet pipes which carried sea water from the Back River to the condenser then overboard to the forebay and discharged through a diffuser in the Back River, downstream of the inlet. The circulating water was considered a "secondary side" system in that there was a physical barrier (condenser tubes and steam generator tubes) between the circulating water and the contaminated primary plant (reactor coolant system). The circulating water system had a very low potential for residual contamination. The operational history of the facility indicated no significant primary to secondary leakage occurred. Additionally, the circulating water system pressure was maintained above the pressure of the turbine exhaust steam in the condenser so that even if there was a condenser tube leak, it would have carried sea water into the condensate system. During Initial Site Characterization, low levels of detectable activity were identified on the main condenser outlet side of the circulating water system. The suspected cause of the contamination was recirculation of allowable effluent discharges into the suction side of the Circulating Water Pump House. The maximum fixed point total surface

contamination measurement collected during ICS was 811 dpm/100 cm<sup>2</sup>. No removable contamination was identified in the system. Gamma isotopic samples collected in the system during ICS did not identify any plant-derived nuclides.

- e. Service Water System (D0600): The Service Water System consisted of two buried inlet pipes which carried sea water through the component cooling heat exchangers. The discharge of the system consisted of a single buried line which goes into the seal pit.

The discharge side of the pipe received the liquid effluent discharge pipe. During initial site characterization (ICS), low levels of detectable activity were identified on the discharge side of the piping. No direct beta measurements were above the MDA. Nine samples of removable beta activity were detected above the MDA (3134 dpm/100cm<sup>2</sup> was the maximum value). The positive indications of residual activity in this system were associated with the liquid effluent header location and the liquid radwaste radiation monitor installed at that location. Gamma isotopic samples collected at the liquid effluent line entrance point and at the radiation monitor were positive for Co-60 (700 pCi/g). The waste header is contained within its own local Restricted Area within the Turbine Building.

The radwaste piping was removed and disposed of as radioactive waste. The remaining portions of the service water discharge piping meet the criteria of a Class 3 area.

- f. Fire Protection (D0700): The water-filled portion of the fire protection system is the only section that remains following demolition. Water for firefighting was stored in a man-made storage pond located on site. Makeup water for the pond came from Montsweag Brook. (The storage pond was addressed as part of survey area R0900). The fire protection system was not piped to containment. The system consisted of a loop of buried pipe which circles the yard and supplies various hydrants and headers. The fire protection system was considered a "support system" in that it did not interface with other operating systems (e.g., primary coolant or steam supply). The fire protection system had a very low potential for residual contamination. Although sections of the system did reside within the RA, system pressures were sufficient to prevent inleakage. The fire water system was cross-connected with potentially contaminated systems in the past. However, samples collected during CCS only identified naturally occurring radioactive material. The maximum fixed point total surface contamination measurement taken during ICS was 1116 dpm/100 cm<sup>2</sup>. Gamma isotopic samples collected during ICS did not identify any plant-derived radionuclides in the system.

- g. Storm Drains (D3500): The Storm Drain (SD) system was used to drain storm water and runoff from the facility to the Back River and Bailey Cove. The system functioned as a gravity drain system to remove the water via a system of drain grates, manholes and system piping. The system drained the entire site both inside and outside the Protected Area. Manholes 1 through 3 (Section 1 of the system) drained the Protected Area outside the Restricted Area and south of the Turbine Building and Service Building. The outfall for this portion of the system was a 24" line that drained to the Back River south of the Circulating Water Pump House (CWPH). Manholes 4 and 5 (Section 2 of the system) drained an area inside the Protected Area outside the Restricted Area east of the Turbine Building. This line drained the area around the Main Transformers. The outfall for this leg of the system was a 15" line that drained to the Back River north of the CWPH. Manholes 6 through 11 and un-numbered manholes north of the Turbine Building (Section 3 of the system) drained an area both inside and outside the Protected Area. The area drained was all outside the Restricted Area. These legs all collected at Manhole 7 and the combined outfall was routed to the Back River immediately adjacent to the north side of the CWPH. Manholes 13 and 14 (Section 4 of the system) drained the upper access road and the upper contractor parking lot. The outfall for this section of the system was the Back River north of the Information Center building. Manholes 30A, and 31 through 37 (Section 5 of the system) drained an area inside the Protected Area in the Restricted Area. This leg of the system drained the main RCA Yard area around the Containment Building and the alley between the Containment Building and the Service Building. These legs all collected at Manhole 35 and the combined outfall was routed to the Forebay Seal Pit. Manholes 21 through 24 (Section 6 of the system) drained the north side of the Restricted Area and the roof of the WART Building. The area drained was inside the Protected Area and both inside and outside the Restricted Area. The combined outfall for this leg joined another leg at Manhole 27. Manholes 25A, 25B, 26 through 29 and 38 (Section 7 of the system) drained areas adjoining the Fire Pond and Warehouse and outside the west end of the Restricted Area. The outfall from Manhole 24 joined this leg at Manhole 27. The combined outfall for this leg of the system was routed to Bailey Cove.

Samples collected during ICS and knowledge of process indicated that the Storm Drain system had a low potential in some legs and a high potential in some legs for residual contamination. Sections 1 through 4 had a low potential for residual contamination. Sections 5 through 7 had a high potential for residual contamination. Sections 1 through 4 drained areas that had historically been outside the Restricted Area and had a low potential for residual contamination. Sections 5 through 7 drained areas in and adjacent to the Restricted Area and may have become contaminated due to loose surface contamination in and on yard structures and equipment being washed into the drain legs by rain water runoff and snow melting.

Since the roof drains flowed to the storm drains and the portions of the roof drains above 17 feet were removed, the roof drains were included in the storm drain survey.

- h. Containment Building Penetrations (D3700) (411ft): Several Containment Building penetrations remain following demolition of the above grade structure. The penetrations contain embedded piping from numerous primary and secondary systems. The remaining penetrations are as follows:
- Approximately 20 linear feet of up to 1" piping
  - Approximately 35 linear feet of 1.5" piping
  - Approximately 50 linear feet of 2" piping
  - Approximately 35 linear feet of 3" piping
  - Approximately 55 linear feet of 4" piping
  - Approximately 100 linear feet of 6" piping
  - Approximately 45 linear feet of 8" piping
  - Approximately 5 linear feet of 10" piping
  - Approximately 25 linear feet of 16" piping
  - Approximately 10 linear feet of 24" piping
  - Approximately 20 linear feet of 30" piping
  - Approximately 11 linear feet of 40" Fuel Transfer Tube piping

Each of these penetration, except for the Fuel Transfer Tube, consists of a five foot length of pipe penetration through the containment foundation wall. The calculated surface area of this embedded piping is approximately 78 m<sup>2</sup>.

- i. The Primary Auxiliary Building and Spray Building Penetrations (60ft). Several non-containment piping penetrations through the Primary Auxiliary Building and Spray Building will remain in the respective building foundations following demolition of the above grade structure. Each of these penetrations consists of a 2 to 3 foot length of pipe penetration through the building foundation wall. The calculated surface area of this embedded piping is approximately 19.5 m<sup>2</sup>.
- j. The spent fuel pool liner leak detection system (24ft). Four 1 inch lines embedded in the spent fuel pool structure will remain following demolition of the above grade structure. The calculated surface area of this embedded piping is approximately 1 m<sup>2</sup>.

The penetrations that will remain in the Containment Building had a high potential for residual contamination. One of the systems identified as having a remaining section of embedded piping was Containment Spray, which was known to contain residual contamination.

ICS data collected in the Containment Spray system (C0300) indicated the presence of removable contamination and gamma isotopic samples



identified the presence of plant related radionuclides. ICS were not collected in the Fuel Transfer Tube. Additionally, no specific contamination controls have been established for the remaining sections of the embedded piping and the majority of the Containment Building is posted and controlled as a surface contamination area.

#### 2.4.8 Asphalt, Gravel and Concrete

Two site locations containing asphalt and gravel from non-RA construction work were sampled for activity (R0700 and R1500). Neither location showed activity above background for plant-derived nuclides.

Because of the potential impact of concrete on the exposure pathway, concrete core samples were collected and analyzed during initial characterization (ICS) (A9900, A9901, A9902) and continuing characterization (CCS). In 1998, GTS Duratek took seven (7) concrete core samples that were later subjected to analysis by Stone and Webster to determine HTD nuclides at low MDC's. In 1999, forty-three (43) additional concrete core samples were obtained and analyzed by gamma spectrometry. In 2000, an additional eight (8) concrete cores were collected and analyzed for HTD nuclides at low MDC's. Table 2C-2 lists the original 43 cores (1-1A through 11-2A) taken during continuing characterization plus the 8 additional cores (12-1A through 13-3A) collected in 2000 for a total of 51 cores. Three of the cores (3-1A through 3-3A) were activated concrete and are labeled as "activation samples" in Table 2C-2. Four samples (5-6A, 6-5A, 6-6A, and 7-2A) had no reported activity. Section 2.5.3a discusses the establishment of the nuclide mixture for contaminated concrete surfaces. See Attachment 2F for a description of the process used to evaluate the concrete surface nuclide mixture. See Attachment 2G for additional discussion of concrete core sample collection and processing.

Concrete activity was found to be due to penetration of surface contamination as well as activation of concrete constituents in areas exposed to neutron flux. (Activated concrete comprised approximately 5% of the concrete in containment.) Surface contamination penetration was primarily limited to the top 0.1 cm. Activation activity generally followed expected activation curves, peaking at 1 to 2 inches into the concrete, and dropping off at greater depths (A9902). Slight anomalies in concrete activation were noted in the vicinity of embedded rebar. Positive indications of activation were seen as deep as 24 inches in some concrete samples that were exposed to high neutron fluence. Activated concrete was removed down to the activated concrete DCGL.

As part of CCS, samples of local fill material (sand, gravel, and till) were analyzed for bulk density and Kd. Activated Concrete at levels above the activated concrete DCGL was removed.

#### 2.4.9 Paved Areas

One paved area near the warehouse (R0900) exhibited one elevated exposure reading. A small contaminated area was removed during sample collection and was found to contain a small amount of Co-60. Resurvey confirmed removal of the contamination. Paved areas within the RA are known to have sub surface asphalt and sub surface soil contamination as described in the "Historical Site Assessment" section.

#### 2.4.10 Components

The status of individual components is given in the systems data, Groups C and D. Group C components are found in radioactive systems and are known to be contaminated.

Section 2.4.3 describes the affected components in Group C; Section 2.4.4 describes the unaffected components in Group D, and Attachment 2B provides a detailed summary of components during ICS.

#### 2.4.11 "Structures, Systems and Environs Surveyed For Hazardous Material" (Groups E and H)

These surveys identified expected amounts of waste chemicals, lubricants and solvents; toxic metals in switches; and PCBs in paints and cables. Some areas of soil contamination by motor oils/fuels were discovered which required further evaluation. Initial characterization activities (ICS) confirmed the presence of lead-based paint and PCBs in both cables and paints. Several small areas of soil were found to be contaminated by chemical or hazardous material.

Hazardous material health and safety considerations will be assessed through the RCRA closure process described in Section 8.6.2.

#### 2.4.12 Surface and Groundwater

ICS sample results for surface and groundwater were reported within the individual survey area packages (R0100, R0200, R0300, R1100, R2200 and R2400) and are summarized in Attachment 2B.

Tritium was the only plant derived radionuclide detected in groundwater and surface water during ICS. The overall range of the tritium analyses was <793 pCi/L to 6812 pCi/L. The highest value was from the Containment foundation sump. All of the measurements were well below the EPA Drinking Water MCL of 20,000 pCi/L. The Containment foundation sump was monitored and trended as part of CCS.

### 2.4.13 Background

ICS measurements were made of several types of construction materials from offsite locations which were used as background samples. Soil samples from remote locations were also taken and analyzed to be used as background soils.

ICS material backgrounds (concrete, brick, ceramic, etc.) were subtracted from reported ICS data direct measurements of total beta activity. ICS environs background (soil, sediment, water, etc.) were collected for informational purposes only. ICS environs background data were not subtracted from ICS environs survey reported data.

#### a. Material Background

The natural levels of radioactivity in plant construction materials affected direct measurements for total beta activity. To quantify this effect, GTS Duratek performed a background study (ICS) at the Central Maine Power Headquarters Building in Augusta, Maine. The study included direct measurements for total beta activity on painted and unpainted concrete and concrete block, ceramic tile, and asphalt. Other materials encountered during the initial characterization survey (ICS) such as glass, carpeting, and steel were not included in the background study since their natural radioactivity would not contribute significantly to direct measurements for total beta activity. Survey personnel used the same instruments for the structural background survey as were used for the initial characterization survey (ICS). Count times were adjusted to ensure minimum detectable activities of approximately 300 dpm/100 cm<sup>2</sup>. Project personnel used these results to correct data gathered from similar surfaces during the initial characterization survey (ICS).

The following is a summary of ICS material backgrounds:

<b>Table 2-4</b> <b>Summary of ICS Material Backgrounds</b>	
<b>MATERIAL</b>	<b>AVERAGE (dpm/100cm<sup>2</sup>)</b>
Bare Concrete (& block)	665
Painted Concrete (& block)	478
Asphalt	925
Ceramic Tile	1109
Other (duct, bare & painted metal, etc.)	0

b. Environs Background

The purpose of the environs background study was to measure and document the levels of radionuclides, especially Cs-137, present in local soils and typical background exposure rates. The survey sampling and measurement techniques complied with approved procedures and supporting guidance documentation. Sample materials for the background study included surface soils, sediments and groundwater. The project team performed gamma spectroscopy for all samples, and analyzed groundwater for tritium. The average Cs-137 concentration in soils was determined from samples collected at the Merrymeeting Airfield, from a hay field, woodlands, and scrub lands. The average Cs-137 concentration in marine sediments was determined from samples collected from the Damariscotta River, near Dodge Point and Harpswell. Groundwater concentrations were determined from the Eaton Barn, Bailey House, and Days Ferry. No groundwater samples had detectable Cs-137 or tritium concentrations (above MDA).

The survey also included an *in situ* gamma spectrum with a MicroSpec multichannel analyzer/sodium iodide detector. Survey technicians measured background exposure rates with a sodium iodide detector. Additionally, the survey team took both sodium iodide and pressurized-ion chamber (PIC) measurements at each of the background soil sample locations in the hay field at Merrymeeting Airfield to observe the energy response of the PIC versus the sodium iodide detector. The project team calculated the background exposure rate and PIC measurement ratio for information and did not use the results to adjust any other measurements.

The following is a summary of ICS environs background data:

<b>Table 2-5 Summary of ICS Environs Background Data</b>			
<b>MEDIA</b>	<b>MINIMUM</b>	<b>MAXIMUM</b>	<b>AVERAGE</b>
Sediment Cs-137	0.04 pCi/g	0.11 pCi/g	0.07 pCi/g
Soil Cs-137 (Combined)	0.09 pCi/g	1.42 pCi/g	0.45 pCi/g
Soil Cs-137 (Woodland)	0.1 pCi/g	0.92 pCi/g	0.52 pCi/g
Soil Cs-137 (Hay Field)	0.1 pCi/g	0.55 pCi/g	0.38 pCi/g
Soil Cs-137 (Scrub Lands)	0.09 pCi/g	1.42 pCi/g	0.55 pCi/g
Water H-3	<743 pCi/L	<3126 pCi/L	<2024 pCi/L

<b>Table 2-5 Summary of ICS Environs Background Data</b>			
<b>MEDIA</b>	<b>MINIMUM</b>	<b>MAXIMUM</b>	<b>AVERAGE</b>
Wood & Scrub Land Exposure (NaI <sub>2</sub> )	5.9 µR/hr	8.3 µR/hr	7.2 µR/hr
Open Land Exposure (NaI <sub>2</sub> )	10.0 µR/hr	13.6 µR/hr	11.6 µR/hr
Open Land Exposure (PIC)	7.18 µR/hr	9.34 µR/hr	8.22 µR/hr

c. Miscellaneous Background Survey Data

The University of Maine (Dr. C. T. Hess) performed a radiological soil and sediment background study prior to plant operations and reported the data in EPA Technical Note ORP/EAD-76-3. The study included analysis of nine soil samples, two marine sediment samples, and seven water samples collected in the vicinity of Maine Yankee prior to plant operations in during 1972.

The following is a summary of miscellaneous background survey data:

<b>Table 2-6 Summary of Miscellaneous Background Survey Data</b>			
<b>MEDIA</b>	<b>MINIMUM</b>	<b>MAXIMUM</b>	<b>AVERAGE</b>
Sediment Cs-137	0.35 pCi/g	0.45 pCi/g	0.4 pCi/g
Soil Cs-137	0.8 pCi/g	4.96 pCi/g	2.04 pCi/g
Water H-3	<90 pCi/L	<400 pCi/L	<294 pCi/L

2.4.14 Waste Volumes and Activities

Table 3-8 summarizes projected activities associated with various sources of radioactive waste materials generated during decommissioning.

2.5 Continuing Characterization (CCS)

The site's initial characterization work (ICS) left a few survey areas unresolved with respect to the nuclides present and the extent or boundaries of contamination. Those areas were characterized during the Continuing Characterization Survey (CCS) effort, which included obtaining the following data:

- Soil samples from the southeast fence area for bounding the extent of contamination
- Soil samples from the contractor's parking lot to confirm remediation and support construction of the ISFSI
- Soil samples from Bailey Point to confirm remediation
- PCC/SCC survey to bound the extent of contamination
- Condensate/Auxiliary Condensate survey to bound the extent of contamination
- Service Water survey to bound the extent of contamination
- Concrete cores
- Forebay/diffuser media
- Groundwater

The new Spent Fuel Pool Decay Heat Removal System was removed and disposed of as radwaste. Additional sampling of the circulating water discharge Forebay was performed to assure compliance with specific unrestricted use release criteria.

Characterization samples will be collected and analyzed to support the decommissioning of the ISFSI and associated areas. In addition, radiation surveys of the ISFSI storage pads are conducted on a periodic basis during the interim storage period.

#### 2.5.1 Methods

Methods employed for continuing characterization were consistent with those described in Section 2.3 for site characterization. Any differences between the methods used by GTS (ICS) and the methods employed for Continuing Characterization (CCS) are noted within Section 2.3.

The work was performed under the guidance of a Decommissioning Work Order (DWO) and in accordance with approved procedures. In order to ensure comparable results, the instrumentation used during CCS was similar in design, function and sensitivity to that used during initial characterization.

#### 2.5.2 Results

The range of residual radioactivity existing on surfaces and within soils and systems targeted for sampling during Continuing Characterization (CCS) are summarized below. Detailed data including mean, maximum, and standard

deviation are presented by survey package in Attachment 2D. The standard deviations calculated from CCS data were replaced with more appropriate values calculated from post remediation or post demolition survey data. This section provides summary results from CCS. The current, resulting nuclide fractions are describe in Section 2.5.3.

a. Stone & Webster Review of the GTS Report (ICS)

Upon review of the GTS Duratech report (ICS), Stone & Webster identified areas requiring additional characterization as follows:

1. Determine the extent of soil contamination at the Southwest fence (CR0200, CR1000<sup>5</sup>) - The East/West boundaries of the soil contamination were determined by gamma spectroscopy of soil samples. In addition, soil was sent for radiochemical analyses in order to confirm the ratio of radionuclides including the hard-to-detect nuclides.
2. Verify remediation of the "contractor parking lot" contaminated areas (CR1300) - Contrary to the GTS report and prior to continued characterization activities commencing, the State of Maine reported that the soil in the parking lot still contained Co-60 contamination after remediation. Soil survey results verified that there was residual soil contamination. The contaminated soil was excavated and disposed of as radwaste. A sample matrix was developed for post-remediation surveys and soil samples were taken and counted. Following this cleanup, the parking lot was determined to be successfully remediated based on gamma spectroscopy of soil samples and gamma scans taken over the affected soil area.
3. Verify remediation of the Bailey Point soil storage area (CR0500) - A sample matrix was developed and soil samples were taken and counted. Based on gamma spectroscopy results, the Bailey Point soil storage area was determined to have been successfully remediated, pending final status survey.

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<sup>5</sup> Note: Survey package numbers, as initially established for characterization, are listed in Section 2.3.7. To distinguish a given package's data from the characterization phase to the Final Status Survey (FSS) phase, a convention was adopted. A preceding "C" was added (to the package number) to indicate the "characterization" and a preceding "F" would be used to denote the "FSS" phase of the project. Thus, "CR0200" in the LTP text refers to the survey package containing characterization data for survey package R0200.

4. Bound the extent of contamination in the PCC and SCC systems (CD1900) - PCC was opened and system internals were analyzed by gamma spectroscopy to determine the extent of contamination. The PCC system was found to be contaminated throughout, including the lube oil coolers of the diesel generators. The SCC system contamination was limited to one air conditioner feeding the control room (which had previously been in the PCC system but was later changed to SCC for train separation concerns) and both SCC pump suction elbows. The systems were labeled to show the extent of contamination.
5. Bound the extent of contamination in the Condensate/Aux Condensate systems (CD0100) - Samples were taken from the aux condensate piping, aux condensate receiver, and aux boilers. The samples confirmed that the aux condensate piping and aux boilers were contaminated. The system was labeled to show the extent of contamination.
6. Bound the extent of contamination in the liquid waste discharge line as it enters the Service Water pipe (CD0600) - Samples of the service water system were taken up stream from the point of entry of the liquid waste discharge pipe. The samples confirmed that contamination was limited to the area adjacent to the discharge pipe connection.
7. Additional surveys were designed and implemented to resolve reported positive count rate data on various systems or components in the Turbine Hall.

The activity in the water treatment plant (CD0200) was determined to be Naturally Occurring Radioactive Materials (NORM).

The data obtained during the Continued Characterization Surveys (CCS) are presented in Attachment 2C tables.

Data obtained during all phases of characterization surveys are used to determine the nuclide profile for each media or material. If conditions arise during decommissioning which might affect the nuclide profile, additional sampling will be performed to verify the nuclide profile of any affected medium.



b. Soils

Surface soil was sampled and analyzed for radionuclides during the initial site characterization (ICS). The radionuclides were detected in the top 15 cm of on-site soil in the survey areas encompassing the backyard. Additional data were collected during continued characterization to better establish nuclide profiles. The predominant plant-related, beta-gamma emitting radionuclides detected were H-3, Co-60, Ni-63 and Cs-137. Two sets of higher activity soil samples taken by GTS were composited and subjected to radiochemical analyses for the hard-to-detect nuclides. No TRUs were detected in the composites when analyzed with techniques giving MDAs of 0.01 pCi/g to 1.0 pCi/g. The actual soil nuclide profile is provided in Section 2.5.3.

The samples from each area were analyzed by gamma spec. If the gamma spec results were consistent with reported values, between 240 and 800 g were removed from the sample containers and added to the composite. The amount removed depended on the total number of samples available from each location. The composites were well mixed and counted again to ensure expected results were achieved. The composites were then sent for HTD analysis except for H-3. Tritium was not analyzed because the samples had been in storage for a long time and were exceptionally dry. Samples for H-3 analysis were taken from locations adjacent to the original sample locations. K-40 and Th were not reported because they were not plant-derived nuclides.

During characterization (CCS) a concern was raised about activity in the vegetative layer of soil. As a result, a comparison was performed by counting vegetation and the soil/root ball; there was little measurable activity in the vegetation. Future soil samples will include the surface soil layer but not the protruding vegetation.

Sub-surface soil was sampled and characterized in areas in which there was knowledge or indication of contamination below 15 cm. The nuclide ratios were consistent with surface ratios. In addition, building sub-slab soil characterization was performed during remediation and demolition to determine the presence and extent of any sub-slab contamination. Samples were taken alongside foundation walls or through holes bored through the floor if necessary.

For additional discussion on soil samples and nuclide fraction see Attachment 2I.

c. Systems and Components

Residual contamination on or in plant piping was the result of the

deposition of both fission and activation products. Prior to and during characterization surveys (both ICS and CCS), samples of process piping were obtained to determine which systems were contaminated and the current radionuclide profiles including the hard-to-detect nuclides. The bounds of the contaminated piping were not established initially so systems were opened and surveyed to define the bounds of contamination. Contaminated system components and piping were removed and disposed of as radioactive waste.

Fe-55, Ni-63, Co-60 and Cs-137 made up 99 percent of the system activities determined during initial characterization. TRUs contributed less than 1 percent of the total activity. The major beta-gamma emitter detected in system materials was Co-60 with a range of activity of 1 to 715 pCi/g (MDAs were 0.03 to 5 pCi/g). No additional quantitative gamma analyses for systems or components were conducted during CCS.

d. Buried and Embedded Piping

Buried and embedded piping remaining after demolition received special surveys during the FSS. The nuclides and ratios in piping and contaminated components were consistent with those described in c above since the systems with embedded sections of contaminated pipe were the systems sampled during initial characterization. The nuclide profile is provided in Section 2.5.3. Nearly all of the embedded pipe consists of the through-wall stubs of 1 to 4.5 feet in length. Since the embedded pipe contributes approximately 2 tenths of one percent of the total annual dose rate, it was decided to assume the small lengths of embedded pipe were contaminated with the same source term as the concrete surfaces through which they passed. Buried pipe is considered to be contaminated with the same source term as other contaminated surfaces, and the activity is released into the surrounding soil upon pipe degradation. Buried pipe contributes less annual dose than embedded pipe.

e. Structures-Concrete

Concrete structures, including the ISFSI storage pads and Vertical Concrete Casks, at elevations higher than 3 feet below grade will be demolished. Surfaces (at elevations below 3 feet below grade) were decontaminated to the specified DCGL for unrestricted use criteria. (See Section 3 for details on building demolition.). Four radionuclides, Cs-137, Ni-63, Co-60 and H-3 comprise approximately 99 percent of the radioactivity on concrete surfaces. (Special consideration was given to trench and sump surfaces. See discussion in Section 2.5.3.)

Radioactivity found in the concrete shielding materials in containment was the result of both contamination and activation. Concrete cores were

removed and analyzed in order to estimate the radioactivity levels and nuclide distributions of shielding materials. The predominant radionuclides present in structural (activated) concrete are H-3, Fe-55, Eu-152, C-14, and Co-60 (comprising approximately 98 percent of the activity in activated concrete).

Concrete cores were counted using both hand-held instruments and gamma spectrometers. This information, coupled with the radiochemical analytical data, were used to determine instrument total efficiency  $E_t$  values (reported in Section 5.5.2).

f. Summary of CCS Activities Since Submittal of Revision 0 of the LTP

Since the submittal of Revision 0 of the LTP, several confirmatory samples were collected. Two floor trench concrete samples were taken and submitted for HTD analysis to confirm or rule out some nuclide outliers reported by GTS (ICS) from a trench sample processed by another laboratory.

Three additional Containment Building floor samples and three PAB floor samples were taken to replace the cores consumed during analysis. See Attachment 2G for discussion of concrete core sample collection and processing.

A portion of activated concrete with embedded rebar was sent for analysis on both the concrete and rebar to establish the hard-to-detect nuclide fraction. A comparison of the nuclide profile was made to activation analysis results prepared for MY activated material as well as to published activation data. The results compared favorably in both instances. A core from the in-core instrumentation (ICI) sump was extended to a depth of 22 inches in order to improve the activated concrete profile (i.e., variance of activity with depth; see Table 2-10). The depth profile was used to plan remediation activities for the ICI sump area. The projected post-remediation activity remaining in the ICI sump area was used in the dose calculations described in Section 6.6.2.

Fire pond water samples were taken and analyzed for tritium and gamma emitters. The same was done for the reflecting pond and sediment from the pond was counted to well below environmental LLDs in order to show there were no plant-derived nuclides in the sediment. See Table 2C-3 for results of reflecting pond samples. (Fire pond water and sediment results were not included.) The fire pond was demolished as part of the decommissioning of the plant.

A containment foundation sump water sample was analyzed (including HTDs) to relatively low MDAs. Tritium was determined to be the sole nuclide present in the foundation drains and groundwater based on this analysis. (This finding was consistent with sump water monitoring results from the past years.) See Section 2.5.3.d for additional information regarding site hydrogeology and groundwater sampling, and the establishment of the groundwater nuclide fraction used for dose assessment.

As part of both initial and continuing site characterization, forebay sediment was sampled. To gain additional insight regarding the spatial distribution of contamination and to support further characterization and remediation planning, additional sampling efforts were undertaken. The principal campaign was in Spring 2001 and included the sampling of: (1) sediment around the protective rip-rap (inside the forebay), (2) underwater sediment on the structure floors, (3) exposed material on the forebay ledges near the weir wall, and (4) dike soil material beneath the rip-rap. Diver operations and inspections of the diffuser also provided an opportunity for the sampling of sediment inside the diffuser piping, as well as piping coupons. The characterization of the forebay and diffuser system is summarized in 2.5.3e and described in more detail in Attachment 2H. Section 6.6.9 discusses the associated dose assessment related to these contaminated media.

Additional material background samples were also collected in order to get better sample population statistics.

The results of these additional samples were used with previous data to determine nuclide profiles for each medium or material. In addition, detailed analyses of concrete core data were performed to ensure that the data collected were truly representative of the contaminated concrete on site. The soil and activated concrete data were also re-evaluated to confirm earlier assumptions based on the data reported in Revision 0 of the LTP.

### 2.5.3 Nuclide Profile

One of the purposes of Site Characterization (both ICS and CCS) is to establish the radionuclide profiles for the various contaminated media which provide dose to the critical group. Multiple samples were taken of each type of media in order to determine the nuclides present and their relative fractions to one another. These nuclide fractions are presented by media in the following sections.

#### a. Contaminated Concrete Surfaces (Including "Special Areas")

Multiple concrete cores were analyzed (including HTDs) in order to

determine the nuclide profile for contaminated concrete surfaces. The majority of the potentially contaminated surfaces remaining will be concrete. Other contaminated material, such as buried and embedded pipe, may also remain. The nuclide profile determined for contaminated concrete is assumed to apply to all concrete surfaces. The sample results were averaged over the entire population and the individual samples compared for consistency. As might be expected, the data were somewhat varied depending on the concrete location, spill history, decontamination history, surface coating and age.

The nuclide fraction for contaminated material was established using each of the positively identified nuclides. The non-detected nuclides were assumed not to be present in the mixture. In order to ensure that the elimination of non-detected nuclides at their MDC levels would not significantly affect the results, a sensitivity analysis based on dose was performed. Dose rates were determined for each individual core, for the core average values and for the average of the fractions using all nuclides in the suite at their actual value or their reported MDA, then the analysis was repeated using only the detected nuclides.

Two of the original set of nine cores (both containment floor trench samples) showed evidence of TRUs; however, the values were very near the analytical MDCs. Even so, the TRUs were included in the evaluation of the nuclide fraction. Upon closer examination, the nuclide fraction for the trench samples appeared distinctly different from the other concrete fraction. The trench had a slightly different history of nuclide contact than the floor surfaces in general. Most significantly, water had been drained directly to the trench during the machining of cobalt-containing thermal shield pins and other special evolutions. Based on the sample results from the two trench cores and consideration of the operational trench history, additional sample data were obtained to confirm the non-trench data. From that data, a separate nuclide fraction for the trenches was developed. As discussed Section 6.7, a separate DCGL for trenches was also established. Additional concrete cores were taken and analyzed, revealing other areas in the plant warranting a separate nuclide fraction. See discussion below related to "special areas."

Table 2-7 gives the nuclide fraction for contaminated surfaces that was selected based on the analysis of the characterization data determined by the "average of the fractions" method and decayed to 1/1/2004. Table 2-7 provides the nuclide fraction for the "balance of plant" contaminated concrete surfaces.

Table 2-8 gives the nuclide fraction for special areas in the plant. These

areas include the containment outer annulus trench, the PAB pipe tunnel, and the letdown heat exchanger cubicle. These were separated from the "balance of plant" contaminated concrete surfaces and were chosen based on operating conditions and the presence of TRU contamination. The dose consequences and DCGL for this collection of areas are described in Section 6.7.2.

The data variability for the concrete cores was analyzed on the basis of dose. The significance of any identified variability was judged on its effect on the resulting dose. (See Attachment 2F for detailed discussion of the data analysis.)

<b>Table 2-7 Nuclide Fractions Contaminated Concrete Surfaces ("Balance of Plant" Areas)</b>	
<b>Nuclide</b>	<b>Fraction (as of 1/1/2004)</b>
H-3	2.36E-2
Fe-55	4.81E-3
Co-57	3.06E-4
Co-60	5.84E-2
Ni-63	3.55E-1
Sr-90	2.80E-3
Cs-134	4.55E-3
Cs-137	5.50E-1

<b>Table 2-8 Nuclide Fractions for Contaminated Concrete Surfaces “Special Areas”</b>	
<b>Nuclide</b>	<b>Nuclide Fraction (1/04)</b>
Mn-54	4.03E-04
Fe-55	2.24E-02
Co-60	3.64E-01
Ni-63	3.02E-01
Sr-90	6.87E-03
Sb-125	4.52E-03
Cs-134	2.82E-03
Cs-137	2.89E-01
Pu-238	1.17E-04
Pu-239	8.75E-05
Pu-240	8.75E-05
Pu-241	6.71E-03
Am-241	5.93E-04
Cm-243	4.65E-05
Cm-244	4.45E-05

b. Activated Concrete / Rebar

Activated nuclide ratios were found to be consistent with published values. The major variation with activated concrete was a decrease in total activity with depth in the material as shown by two deep core profile samples. This property can be used to determine the depth of remediation needed. There was also a local effect on nuclide activity and ratio in the area immediately surrounding rebar contained within the concrete.

Two highly activated concrete samples were analyzed for HTDs. As noted in Section 2.5.2f, one portion of activated concrete included embedded rebar. The rebar sample was also analyzed for HTDs. The hard to detect nuclides showed the same level of consistency as the gamma emitters when compared to published values (NUREG/CR-3474). The nuclide fractions for the activated concrete and rebar was established using each of the positively identified nuclides. The non-detected nuclides were assumed not to be present in the mixture. In order to ensure that the elimination of non-detected nuclides at their MDC levels would not significantly affect the results, an analysis based on dose contribution was performed. Annual dose rates were determined for each nuclide at its actual reported value or its MDC, then the analysis was repeated using only the actual reported values of the detected nuclides. Those nuclides included in the dose analysis at their MDC values were shown to contribute less than 10 percent of the annual dose from the pathway analyzed. Table 2-9 gives the nuclide fraction for activated concrete and rebar decayed to 1/1/2004.

Based on the higher dose contributions from activated concrete, in comparison to the rebar, the nuclide fraction for activated concrete was used in the Section 6 dose assessment. See Section 6.6.2.



<p><b>Table 2-9</b>  <b>Activated Concrete Nuclide Fractions</b></p>		
	Concrete as of 1/2004	Rebar as of 1/2004
Nuclide	Fraction	Fraction
H-3	0.647	-----
C-14	0.058	-----
Fe-55	0.124	0.910
Ni-63	0.007	0.006
Co-60	0.040	0.084
Cs-134	0.0084	-----
Eu-152	0.111	-----
Eu-154	0.009	-----

Table 2-10 shows the activity measured a function of depth in the deep core sample.

<p><b>Table 2-10</b> <b>Activated Concrete: Deep Core Sample Activity Profile</b></p>			
<b>Depth (in)**</b>	<b>Activity (pCi/g)***</b>	<b>Depth (in)</b>	<b>Activity (pCi/g)</b>
0 - 0.5	677*	10.75 - 11.5	87
0.5 - 1.0	828	11.5 - 12.25	23
1.0 - 1.5	845	12.25 - 13.0	23
1.5 - 4.0	824	13.0 - 13.75	17
4.0 - 4.75	771	13.75 - 14.5	14
4.75 - 5.5	329	14.5 - 15.25	14
5.5 - 6.25	534	15.25 - 16.0	11
6.25 - 7.0	365	16.0 - 16.75	7
7.0 - 7.75	290	16.75 - 17.5	6
7.75 - 8.5	233	17.5 - 18.25	6
8.5 - 9.25	206	18.25 - 19.0	1
9.25 - 10.0	182	19.0 - 20.0	1
10.0 - 10.75	103		

\*Adjusted to remove Cs-137 surface contamination from the total activity

\*\*Note that the depth column represents a "label" for each sequential slice and is not intended as an exact measurement. The slices were generally ½" to ¾" but were not uniform in thickness. Therefore, while Table 2-10 presents the profile out to 20 inches, this represents all of the data available for the entire 22 inch core.

\*\*\*Measured activity provided in this table includes gamma detectable activity from the nuclides listed in Table 2-9.

c. Contaminated Soil

Soil from the areas with the highest contamination levels (RWST and PWST areas) were composited and analyzed for nuclide content including HTDs.<sup>6</sup> Since the samples used for the composites were very dry, archived soils, no tritium analyses were made. However, tritium analyses were performed on soil samples from an adjacent area.

The nuclide fraction for the contaminated soil was established using each of the positively identified nuclides. The non-detected nuclides were assumed not to be present in the mixture. In order to ensure that the elimination of non-detected nuclides at their MDC levels would not significantly affect the results, an analysis based on dose contribution was performed. Annual dose rates were determined for each nuclide at its actual reported value or its MDC, then the analysis was repeated using only the actual reported values of the detected nuclides. Those nuclides included in the dose analysis at their MDC values were shown to contribute less than 10 percent of the annual dose from the pathway analyzed.

The soil profile given in Table 2-11 is used for both surface (within 15 cm of the surface) and deep (below 15 cm of the surface) soils. The soil fractions were decayed to 1/1/2004.

For additional discussion on soil samples and nuclide fraction, see Attachment 2I.

<b>Table 2-11 Soil Nuclide Fractions</b>	
<b>Nuclide</b>	<b>Fraction as of 1/2004</b>
H-3	0.053
Ni-63	0.048
Co-60	0.009
Cs-137	0.890

d. Groundwater and Surface Water

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<sup>6</sup> Regarding buried and embedded piping and its impact on soil contamination, the most significant of buried/embedded piping within the industrial area are the HPCI and LPCI lines. These contained the same fluid as the RWST and would be well represented by the RWST and the subsequent RWST related soil samples used in part of the soil nuclide fraction.

Samples were taken of the groundwater (containment foundation sump) and the surface water sources (fire pond and “reflecting pond”). The samples were analyzed for gamma emitters and HTDs. Since the samples contained relatively low levels of residual activity, long count times were used to achieve low MDAs. The only nuclide detected in either source of water was tritium. The surface water tritium is naturally occurring. Additional information regarding background tritium in and around the Maine Yankee site is provided in a comprehensive report on site hydrogeology (Stratex, February 2002, Reference 2.7.19).

The February 2002 Stratex report (referenced above) summarized and discussed radioactivity in site groundwater and its relationship to site history regarding releases of contamination.<sup>7</sup> In general, while relatively low levels of Co-60 and Cs-137 have been sporadically detected in the containment foundation sump and other site wells, the primary, consistently detected nuclide is tritium. The nuclide fraction for groundwater (used as an initial condition for the dose assessment) consists of tritium only. See Section 6.6.6 for additional discussion, activity levels, and the use of this nuclide fraction in the dose assessment.

An additional groundwater re-sampling program consisting of fifteen wells was implemented in spring of 2002. The results of this effort, which included the analysis of twelve of the fifteen well samples for “hard to detect” nuclides, were reported in Maine Yankee’s letter to the NRC, dated August 28, 2002 (Reference 2.7.20). This submittal included an addendum to the February 2002 Stratex report (August 2002). This sampling effort included not only the containment foundation sump but also numerous wells in the industrial area as well as several new wells, as recommended in the February 2002 Stratex report. (Additional groundwater exploration of the Primary Auxillary Building “PAB” test pit area, as recommended by Stratex in February 2002, was not pursued. See discussion below.)

Consistent with prior well sampling in the industrial area, the results of this site groundwater re-sampling effort showed relatively low levels of groundwater contamination. Two wells reported relatively low levels of either Co-60 and Cs-137. Tritium levels were above background in several wells; however, they were consistent with previously detected concentrations and well within the conservative levels assumed for dose modeling. Hard to detect analyses (including transuranics) detected no other nuclides, also consistent with prior sampling. (See References 2.7.20 and 2.7.25.) The nuclide fraction for both ground and surface water

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<sup>7</sup> Stratex, February 2002, Section 3.7 (LTP Reference 2.7.19).

is given in Table 2-12.

Special consideration and assessment was given to the isolated detection (1999) of contamination in the PAB test pit, as discussed in the February 2002 Stratex report. Additional study of the fate and transport of relevant nuclides was performed by Stratex, supported by Brookhaven National Laboratory (reported in the August 2002 Maine Yankee submittal to the NRC<sup>8</sup>). Based on the additional study, including consideration of recent sampling of the test pit and the containment foundation sump and site hydrogeology, Maine Yankee concluded that no additional field investigations or groundwater exploration were necessary to further study the fate and transport of the historical PAB test pit contamination. The PAB test pit remains. The applicable final status surveys demonstrated compliance with surface contamination release criteria. (See Reference 2.7.20.)

Samples from the containment foundation sump and the PAB test pit were routinely obtained and analyzed until the final status survey was commenced for these two plant areas. See Section 6.6.6. Furthermore, as noted in Section 6.6.6, future groundwater sampling data obtained prior to unrestricted release was considered for its impact on the dose assessment.

<b>Table 2-12</b>	
<b>Ground and Surface Water Nuclide Fraction</b>	
<b>Nuclide</b>	<b>Fraction</b>
H-3	1.000

e. Forebay and Diffuser Contaminated Media

A detailed discussion of the characterization of the forebay and diffuser system is provided in Attachment 2H. The characterization effort and resulting nuclide fraction for forebay/diffuser media are summarized below.

The forebay (and seal pit) characterization consisted of sampling efforts that identified the following contaminated media:

1. Rock floors and walls of the forebay/seal pit, as well as a limited amount of concrete surfaces at the northern and southern ends of the forebay basin;
2. Rip-rap, contaminated surfaces;
3. Marine sediment deposited on the floors of the forebay/seal pit and

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<sup>8</sup> Reference 2.7.20, as corrected by Maine Yankee letter to the NRC, MN-02-045, dated October 3, 2002 (Reference 2.7.24)

- around the rip-rap; and
4. Dike "soil," i.e., that material beneath the rip-rap, interior to the dike walls.

Sampling and assessment of the diffuser system identified two contaminated media, namely, sediment entrained inside the diffuser discharge piping and contaminated surface film deposited on the inside surfaces of diffuser piping. This surface contamination was noted to be very similar to that on the rip-rap covering the interior forebay dike walls.

As the results of several sampling campaigns (including diving operations), each of the above media were sampled, analyzed, and evaluated regarding nuclides present, activity levels, and relative fractions. The evaluation included three sets of sediment samples analyzed for HTD nuclides. The overall assessment concluded that a single nuclide fraction was appropriate and conservative for application to these media. The nuclide fraction for forebay and diffuser related media is presented in Table 2-13. See Attachment 2H for additional discussion on the principal construction features of the forebay and diffuser system, the sampling campaigns, results, and conclusions. See also EC 041-01 for supporting technical bases and analyses.

<b>Table 2-13</b> <b>Forebay/Diffuser Material Nuclide Fractions</b>	
<b>Nuclide</b>	<b>Fraction (as of 1/1/2004)</b>
Fe-55	0.165
Ni-63	0.233
Co-60	0.567
Sb-125	0.005
Cs-137	0.030

f. Future Sampling

The radionuclide profiles for contaminated concrete, activated concrete, soil, ground water, surface water, and sediment listed in Tables 2-7 and 2-8, 2-9, 2-11, 2-12, and 2-13 respectively, were determined using representative data. These profile results do not rule out the possibility of taking additional samples of these media as decommissioning progresses and as conditions warrant.

Note: If radionuclide profiles are revised, the revised profiles will be

provided to the NRC and the State of Maine at least 30 days prior to their use.

#### 2.5.4 Background Determination

The residual radioactivity of a survey unit may be compared directly to the DCGL; however, some survey units will contain one or more radionuclides which are also contained in background. In order to identify and evaluate those radionuclides, background areas have been established which contain only background levels of the radionuclides of interest. These background areas were chosen because they were similar in physical, chemical, geological and biological characteristics to the survey units.

##### a. Soils

Soil samples were taken (ICS) from the non-impacted areas and analyzed in order to establish general soil background levels. If background "reference" area measurements are required for the Final Survey Program, the reference area measurements will be collected in accordance with the methods described in Section 5 and the applicable approved procedures. The samples showed mean Cs-137 levels of 0.2 to 0.5 pCi/g depending on whether the soil had been disturbed or not. The more undisturbed the soil is, the higher the background Cs-137 may be (e.g. Knight Cemetery, Eaton Farm, values reported in Attachments 2A & 2B). The naturally-occurring uranium isotopes (U-234, U-235, and U-238) were present in expected amounts. Uranium is naturally occurring, not plant derived. These nuclides are not included in the Soil Mixture Nuclide Fraction listed in Table 2-11 above. Sr-90 was not detected at or above a MDC of 0.4 pCi/g.

##### b. Structures

Background measurements were taken on structural materials during initial characterization (ICS) in order to estimate the contribution of background activity to the total measurement value. The same types of detectors will be used for FSS as were used during both ICS and CCS. Background values for structural materials using these detectors are shown in Table 2-14.

<b>Table 2-14</b> <b>Structural Material Backgrounds</b>		
<b>Background Counts per Minute (reflects beta count rate)</b>		
<b>Materials</b>	<b>43-68 Proportional Detector - 126 cm<sup>2</sup></b>	<b>SHP-360 G-M Pancake Detector - 15.5 cm<sup>2</sup></b>
Painted Cinder Block	296**	70**
Wood	301**	57**
Ambient	319**	65**
Steel	277*	46*
Carpet	339**	68**
Floor Tile	359*	62*
Ceiling Tile	439*	73*
Bare Cinder Block	394**	79**
Painted Concrete	392*	74*
Bare Concrete	433*	76*
Asphalt	559*	99*
Granite	566**	128**
Porcelain	607**	116**
Brick	716*	118*

\* Average of twenty-five one minute static counts taken in the scaler mode.

\*\*Average of ten one minute static counts taken in the scaler mode.

The 43-68 proportional detector will generally be used for surface contamination measurements because of its sensitivity, larger detection area and lower MDC. SHP-360 will only be used where a measurement can not be taken with a 43-68 detector.

## **2.6 Summary**

### **2.6.1 Impact Of Characterization Data On Decontamination And Decommissioning**

Characterization data (both ICS and CCS) confirmed what was known about the MY site in terms of the level and extent of radioactive contamination. A major portion (700 acres) of the site met the classification of non-impacted. Primary systems and structures were found to be contaminated to expected levels. Non-RA systems and structures were found to be free of contamination except as previously stated.



There were minimal or no changes in either waste volumes or waste activity values following the performance of site characterization.

The data compiled are sufficient to project schedules and waste volumes, evaluate decontamination techniques, perform dose assessments and evaluate any safety or health issues affecting workers on site.

The HSA and characterization measurement results (ICS and CCS) are sufficient to meet the objectives listed in Section 2.1 and demonstrate compliance with the guidance contained in Regulatory Guide 1.179 and NUREG-1700. The more than 19,000 measurements provide sufficient data to determine the radiological status of the site and facility as well as identify the location and extent of contamination outside the RA. The radionuclide analyses performed were sufficient to estimate the source term and isotopic mixture (based on the achieved standard deviation of the data). The analysis results also provide sufficient information to support dismantlement, radioactive waste disposal, decommissioning cost estimates and remediation decision making processes. The source term information was also suitable for instrument selection. The radiological data were acceptable to develop the necessary quality assurance methods for sample collection and analysis. The data obtained during characterization (ICS and CCS) support dose assessment and FSS design.

## 2.7 References

- 2.7.1 NUREG-1575, Multi-Agency Radiation Survey and Site Investigation Manual, (MARSSIM), Revision 1 (June 2001)
- 2.7.2 10 CFR.50.75, Reporting and Recordkeeping for Decommissioning Planning.
- 2.7.3 Continuing Characterization (CCS) Plan (PMP 6.8).
- 2.7.4 CCS Quality Control (PMP 6.8.4).
- 2.7.5 Corrective Action Program
- 2.7.6 Document Control Program (0-17-1).
- 2.7.7 Radiation Protection Performance Assessment Program (PMP 6.0.8).
- 2.7.8 Selection, Training and Qualification of Radiation Protection Personnel, (PMP 6.9).

- 2.7.9 Maine Yankee Atomic Power Co. (MY), *RCRA Quality Assurance Project Plan for Maine Yankee Decommissioning Project, Revision 1*. (June 28, 2001)
- 2.7.10 NUREG-1507, Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions. (June 1998)
- 2.7.11 NUREG-1700, Standard Review Plan for Evaluating Nuclear Power Reactor License Termination Plans. (April 2000)
- 2.7.12 Regulatory Guide 1.179, Standard Format and Content of License Termination Plans for Nuclear Reactors. (January 1999)
- 2.7.13 NUREG/CR-3474, Long-Lived Activation Products in Reactor Materials.
- 2.7.14 GTS Duratek, "Characterization Survey Report for the Maine Yankee Atomic Power Plant," Volumes 1-9, 1998 (ICS).
- 2.7.15 Dr. Chabot letter to P. Dostie, dated November 12, 1998, discussing determination of MDC
- 2.7.16 Maine Yankee letter to the NRC, MN-02-002, dated January 16, 2002, transmitting special report from the Technical Issue Resolution Process, entitled "Transuranic and Other Hard to Detect Radionuclides in Maine Yankee Sample Media."
- 2.7.17 NRC letter to Maine Yankee, dated July 30, 2002, Issuance of Amendment No. 167, license amendment approving partial release of site lands.
- 2.7.18 Maine Yankee Engineering Calculation, EC-041-01 (MY), Revision 0
- 2.7.19 Maine Yankee letter to the NRC, MN-02-010, dated February 20, 2002, "Maine Yankee Response to NRC RAI #16 (dated December 18, 2001) Addressing Site Hydrogeology," (included submittal of Stratex, LLC, report, *Site Hydrogeology Description, Maine Yankee, Wiscasset, Maine*, February 2002).
- 2.7.20 Maine Yankee letter to the NRC, MN-02-037, dated August 28, 2002, "Maine Yankee Addendum Report Regarding Site Hydrogeology," (including Stratex, LLC, report *Site Hydrogeology Addendum, Maine Yankee, Wiscasset, Maine*, August 2002).

- 2.7.21 Maine Yankee letter to the NRC, MN-02-011, dated March 13, 2002,  
“Response to NRC Request(s) for Additional Information for the Maine  
Yankee Atomic Power Station LTP”
- 2.7.22 MYAPC Historical Site Assessment (HSA), transmitted by MN-01-038  
dated October 1, 2001
- 2.7.23 Maine Yankee letter to the NRC, MN-02-015, dated April 11, 2002,  
“Revised Maine Yankee Response to NRC RAI #5 (dated December 18,  
2001) - Supplementary Historical Site Assessment (HSA) Data”
- 2.7.24 Maine Yankee letter to the NRC, MN-02-045, dated October 3, 2002,  
“Minor Changes to Maine Yankee Responses to NRC Request for  
Additional Information”
- 2.7.25 Maine Yankee Engineering Calculation, EC-006-01 (MY), Revision 2
- 2.7.26 Maine Yankee letter to the NRC, MN-02-063, dated December 12, 2002,  
“Update on Forebay Dike Coring Results and Associated Changes to LTP  
Attachment 2H (LTP Revision 3 Addenda)”

**ATTACHMENT 2A  
Non-Impacted Area Assessment**

## **ASSESSMENT OF THE MY SITE WEST AND NORTH OF BAILEY POINT FOR CLASSIFICATION AS NON-IMPACTED**

### **2A.1 Introduction**

Based on both the Historical Site Assessment and the characterization surveys performed, a large portion of the site located to the West of Bailey Cove and North of the Ferry Road was determined to be non-impacted in the partial site release applications (Maine Yankee Letters dated August 16, 2001 (MN-01-034) and November 19, 2001 (MN-01-044) Early Release of Backlands (Combined) Proposed Change 211, Supplements 1 and 2 respectively). The NRC granted the requested license amendment in its letter to Maine Yankee, dated July 30, 2002. Attachment 2A is maintained for historical purposes.

One aspect of the FSS Plan is the proper classification of areas within the site. Areas must be classified as either: Impacted, Class 1, Class 2, or Class 3; or Non-impacted. Non-impacted areas are defined in NUREG-1575 (MARSSIM) as areas that "have no reasonable potential for residual contamination, no radiological impact from site operations and are typically identified during the Historical Site Assessment." The MY Historical Site Assessment (HSA) did not classify any areas within the site but it did provide data which could be used in conjunction with other information to classify areas. The HSA was not and will not be solely relied upon to make any classification, remediation or survey decision. The source term was well understood through previous Part 61 analysis. The potential pathways for this source term to potentially affect any offsite areas are well understood, described in the Off Site Dose Calculation Manual and monitored on a routine basis.

### **2A.2 Area Description**

Approximately 641 acres of the MY site are found to the West of Bailey Cove, North of the access road (Ferry Road) and bounded by Back River to the east. The land is generally located beyond the 2000 foot exclusion zone established under the requirements of 10 CFR 100. As such, the area has been open and accessible to the general public and is bounded by residential land owners.

The referenced area consists of open fields, woodland and some shoreline property which has been uninhabited and unfarmed since plant construction started in 1968. The geology and hydrology of the area has been described in detail in the MY FSAR and is physically similar to the operating area of the site itself except for there being little or no surface soil disturbance (except for the ash pit and the ash pit access road). Structures in the area generally predate the construction of the plant.

The meteorology of the area has been characterized in detail in terms of annual precipitation, prevailing winds and stability class. Average annual precipitation exceeds the US average. Prevailing winds are from the South but a sea breeze blows East to West.

### **2A.3 Historical Site Assessment**

The land areas under consideration are approximately 0.25 miles or more from the Reactor Building and process buildings. No radioactive material was used or stored beyond the peninsula of Bailey Point. License restrictions and administrative controls have been in place since power operations began in 1972 to prevent unauthorized removal of radioactive material from the owner controlled area. Planned offsite releases of radioactive material were limited to the permitted effluent releases (which were kept ALARA by process controls) and radioactive solid waste which was shipped to licensed burial sites. The HSA, as supplemented, documented approximately 140 actual or potential events involving unplanned releases of radioactive material or hazardous material during the 25 year operating history of the plant. Of these events, about two thirds involved or potentially involved radioactive material. Based on a review of the documentation assembled in the HSA, none of these events would have resulted in residual contamination of the area under consideration. Therefore, there is no reasonable potential for residual contamination in the area.

### **2A.4 Radiological Environmental Monitoring Program**

A Radiological Environmental Monitoring Program (REMP) was instituted prior to operation of the plant and continues to the present time. Environmental measurements taken have included thousands of gamma dose rates, hundreds of air and water samples, and hundreds of food stuff and surface vegetation samples. The key indicators of radiological impact in the area of concern are TLD measurements, air samples, water samples, vegetation samples, food crop samples and sediment samples.

TLD measurements have shown no difference in dose rates between the area under discussion and the control areas further from the site. Bailey Farm well water had slightly lower tritium levels on average than the water supplies in the Wiscasset area. Precipitation tritium levels at local sampling stations (Eaton and Bailey Farms) were similar to the control station levels. Fruits and vegetables sampled at the Bailey Farm showed the presence of only K-40 and fallout-produced Cs-137. Grasses sampled at the Eaton and Bailey Farms showed only natural K-40 and fallout-produced nuclides during periods of atmospheric testing. Initial soil samples had Cs-137 at levels consistent with published values for fallout activity. Samples taken during the intervening period had Cs-137 levels consistent with that which should have resulted from the decay of the initial 1970 sample activity. No radionuclides of plant origin were detected in these areas.

### **2A.5 Special Surveys And Reports**

The HSA and other sources document samples (or measurements) of radiation and radioactive materials taken in the area in question. Pressurized ion chamber readings, TLD measurements, soil samples and even a "fly over" dose rate survey have documented radiation levels in the area

similar to, or slightly less than, those measured in pre-operational surveys. The slight decline in levels is likely due to decreased levels of fallout-produced Cs-137 (Aerial Radiation Measurement Study, 1974 and University of Maine, 1974 and 1997). Some anomalous Cs data for Knight Cemetery, Eaton Farm and Foxbird Island can be understood in light of normal spacial variability in activity related to differences in sampling locations and the relatively undisturbed nature on some of these locations. Table 2A-7, "Alternate Table of Cs-137 Activity," shows very consistent results and the impact of decay when 1970 and 1997 data are presented. It is not surprising that some of the Cs data increased with time up to 1974 since atomic weapon atmospheric testing was still being conducted up to 1974.

Based on NUREG-1575 guidance, classification of an area as "not impacted" can be made solely on the Historical Site Assessment. Rather than rely solely on the HSA, the area in question was subjected to site characterization surveys. During 1997 and 1998, GTS performed site characterization measurements in the area which included gamma dose rates determined by pressurized ion chamber and micro R meter, soil samples and "drive around" surveys using a vehicle-mounted 1.5"x 3"x 33" scintillation detector. The characterization surveys (PIC and "drive around") in the area produced one area with an elevated radiation level. Upon investigation, the elevated reading was found to be due to local increase in naturally occurring radiation. Approximately 150 soil samples taken throughout the area showed only background levels of radioactive material in quantities slightly less than those reported in the 1972 pre-operational studies in this area which is consistent with the decay of the fallout-produced activity.

#### **2A.6 Backlands Report**

On August 16, 2002, Maine Yankee submitted an application<sup>1</sup> for amendment to its license to release these backlands from the jurisdiction of the license. This application was supplemented<sup>2</sup> on November 19 2001. In the supporting justification attached to the application, Maine Yankee reviewed the soil sample Cs-137 results of the Initial Characterization Survey (ICS) to determine if the residual radioactivity, if any, in the backlands is indistinguishable from background and thereby support the classification of "non-impacted".

Demonstrating indistinguishability from background employs MARSSIM Scenario B. In Scenario B, the null hypothesis is that the survey unit meets the release criterion (indistinguishable from background). Under Scenario B, the comparison of measurements in the reference area and survey unit is made using two nonparametric statistical tests: the Wilcoxon Rank Sum (WRS) test and the Quantile test. The WRS and Quantile tests are both used because

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<sup>1</sup> Maine Yankee Letter to USNRC dated August 16, 2001, "Early Release of Backlands (Combined), Proposed Change No. 211, Supplement No. 1, (MN-01-034)

<sup>2</sup> Maine Yankee Letter to USNRC dated November 19, 2001, Early Release of Backlands (Combined), Proposed Change No. 211, Supplement No. 2, (MN-01-044)

each test detects different residual contamination patterns in the survey units. Because two tests are used, the Type I error rate,  $\alpha$ , (normally set at 0.05) is halved, and set at 0.025, for the individual tests. Using the NUREG-1505 recommended  $\alpha$  of 0.025 allows for the use of the look-up tables in NUREG-1505, for r and k values used in the Quantile test.

The WRS test is designed to determine whether or not a degree of residual radioactivity remains uniform throughout the survey unit. The Quantile test is designed to detect a patchy contamination pattern.

Table 2A-8 contains the soil sample Cs-137 results for the background reference area. The background reference area consisted of area surrounding the Merrymeeting Airfield located approximately 10 miles from the site and was representative of site characteristics. The Kruskal-Wallis test was used to confirm that there was no significant difference in the mean background concentrations among potential reference areas.

Table 2A-9 summarizes the results of the soil sample Cs-137 results for the backlands areas and compares them to the results for the background reference area. For each of the backlands areas, the results of the WRS test, where applicable<sup>3</sup>, and the Quantile test successfully demonstrated that the residual radioactivity, if any, in the areas was indistinguishable from background.

## **2A.7 Conclusion**

Based on the evaluation of the historical use of the area, the lack of use or storage of radioactive material in the area, the Historical Site Assessment findings, the REMP results, the results of the site characterization surveys, and the demonstration of indistinguishability from background described in the Backlands Report, the area to the West of Bailey Cove and North of Ferry Road within the land owned by MY has been classified as non-impacted.

The area lends itself to use as a background reference area for soil samples and may be used as such during the FSS. Random sampling of soil in order to establish background activities may be performed in this reference area, but no systematic sampling as required by MARSSIM for impacted areas will be performed.

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<sup>3</sup> For area R-1500 Ash Rd. Rubble Piles, the maximum Cs-137 reading was less than the value known as the Upper Boundary of the Grey Region; therefore, the application of the WRS test was not necessary to demonstrate indistinguishability from background.



Table 2A-1 RADIOLOGICAL ENVIRONMENTAL DATA				
TLD DATA (Mean Value in $\mu\text{R/hr}$ )				
Data Source	Inner Ring	Outer Ring	Control	Period; # locations
MY	11.8	12.0	11.9	1970-1972 n=9
MY	7.1	7.4	7.8	1990-1997 n=28
Univ. of Maine	8.2	8.6	9.3	1971-1996 n=87

Table 2A-2 Pressurized Ion Chamber Data ( $\mu\text{R/hr}$ )				
Data Source	Location	1971	1996	1998
Univ. of Maine	Bailey House	9.5	8.8	
Univ. of Maine	Eaton Farm	9.5	9.3	
Univ. of Maine	Westport	11.4	9.1	
Univ. of Maine	Knight Cemetery		8.7	
Univ. of Maine	Long Ledge		9.0	
GTS	Merrymeeting Airfield			Mean=8.2 Range: 7.2-9.8 n=300

Table 2A-3 Soil Cs-137 (pCi/g)					
Sample Location	1970 MY	1972 MY	1974 MY	1996 MY	1997 GTS Characterization
Bailey House	0.64	1.67	1.8	0.4	0.21; n=30
Bath	0.66				
Dresden	0.58				
Eaton Farm	0.53	0.87	2.5	0.09	0.45; n=60
Edgecomb	0.48				
Foxbird		0.35		0.48	
Knight Cemetery		4.96		2.42	
Long Ledge		0.80		0.38	
Harrison's	0.52				
Mason Station	0.68				
Montsweag Dam	0.42				
Westport	0.56	1.11		1.03	
North of Ferry Road					0.39; n=60
Merrymeeting Airfield					0.42; n=60
Shoreline					0.20; n=30
Mean Value	0.56	1.63	2.15	0.80	0.32

<b>Table 2A-4</b> <b>Surface &amp; Well Water Data</b>	
<b>Sample Location</b>	<b>(Mean H-3 pCi/L) 1977-1984</b>
Bailey House	235
Montsweag Dam	276
Morse Well	187
Biscay Pond	297
Wiscasset Reservoir	278

<b>Table 2A-5</b> <b>Precipitation Data</b>	
<b>Sample Location</b>	<b>(Mean H-3 pCi/L) 1977-1982</b>
Bailey House	416
Eaton Farm	417
Westport	422
Dresden	397

Table 2A-6 Air Particulate Data (Mean Gross Beta Activity, pCi/m <sup>3</sup> )			
MY Pre-Operational Data			
1970		0.12	
1971		0.12	
1972 Jan-Jun		Zone I=0.06, Zone II=0.07	
Univ. of Maine 1981-1997		MY 1988-1998	
Wiscasset	0.02*	Montsweag	0.021
Augusta	0.02*	Bailey House	0.020
		Mason Station	0.020
		Westport	0.021
		Dresden	0.022

\* Values estimated by graph. Individual data not available.

References: MY data were taken from the REMP Reports for the time periods listed or the GTS Characterization Report.

University of Maine data were taken from "A Radiological Survey of the Area Surrounding the MY Nuclear Plant", March 1997.

Table 2A-7 Alternate Table of Cs-137 Activity		
Soil Cs-137 (pCi/g)		
Sample Location	1970 MY	1997 GTS Characterization
Bailey House	0.64	0.21; n=30
Bath	0.66	
Dresden	0.58	
Eaton Farm	0.53	0.45; n=60
Edgecomb	0.48	
Harrison's	0.52	
Mason Station	0.68	
Montsweag Dam	0.42	
Westport	0.56	
North of Ferry Road		0.39; n=60
Shoreline		0.20; n=30
Mean Value	0.56	0.32

Table 2A-8 Reference Area Soil Sample Cs-137 Results pCi/g			
Reference Areas - Merrymeeting Airfield	Mean (Ave.)	Std. Dev. (1 $\sigma$ )	Number of Samples
Combined (wood, open & scrub)	0.42	0.21	50
Wood Land	0.47	0.24	10
Open Land (Hay Field)	0.38	0.12	30
Scrub Land	0.48	0.34	10

Table 2A-9 Soil Sample Cs-137 Results					
Area Description	Minimum Cs-137 pCi/g	Median Cs-137 pCi/g	Average Cs-137 pCi/g	Maximum Cs-137 pCi/g	Number of Measurements
Reference Area R2200	0.09	0.38	0.42	1.40	50
Survey Unit R1500* Ash Rd. Rubble Piles	0.02	0.06	0.07	0.21	30
Survey Unit R1600 Eaton Farm	0.05	0.39	0.45	1.43	60
Survey Unit R1700 North of Old Ferry R.	0.04	0.30	0.39	1.55	60

\* Disturbed open land area within R1700 North of Ferry Rd.

**ATTACHMENT 2B**  
**Characterization Data**

Table 2B-1  
Group A  
Radiological Characterization Results For Affected Structures and Surfaces

	Direct Beta DPM/100 cm <sup>2</sup>			Removable Beta DPM/100 cm <sup>2</sup>			Removable Alpha DPM/100 cm <sup>2</sup>			Exposure Rate MicroR/hr		
Package	Mean (MDC)	Maximum	Std. Dev.	Mean (MDC)	Maximum	Std. Dev.	Mean (MDC)	Maximum	Std. Dev.	Mean Minimum Detectable Exp Rate (MDER)*	Maximum	Std. Dev.
A0100 Cont.El -2 Ft	81,976 (30,453)	1,970,974	259,134.5	296 (33)	4,282	598.7	0.0 (8.4)	2.4	0.5	2,375 (15)	4,065	816
A0200 Cont. El 20 Ft	62,970 (16,277)	2,238,614	247,399.2	2,388 (35)	128,734	13,577.2	0.7 (9.7)	7.3	1.6	887 (15)	1,961	463
A0300 Cont. El 46 Ft	38,444 (16,058)	345,960	55,889.2	1,469 (33)	31,054	3245.7	0.2 (8.7)	5.8	1.1	499.5 (15)	2,408	387.5
A0400 Fuel Bldg El 21 Ft	6,815 (12,436)	312,939	32,365.4	38.4 (32)	879	106.2	-0.1 (8.5)	1.8	0.6	706.6 (15)	2,901	649.7
A0500 DWST	438 (2,322)	2,659	792.6	4.9 (32)	20.3	7.0	0.1 (8.4)	3.9	1.0	14.0 (15)	14.6	0.9
A0600 PAB El 11 Ft	1,106 (13,168)	32,328	7513.5	5.2 (32)	32.3	8.0	-0.1 (8.5)	3.9	0.7	1,100 (15)	3,477	827
A0700 PAB El 21 Ft	460 (15,837)	25,000	4655.1	5.9 (32)	51.5	9.7	-0.2 (7.7)	1.8	0.3	581 (15)	4,068	950
A0800 PAB El 36 Ft	508 (18,042)	14,073	2166.5	5.9 (34)	94.2	11.0	0.1 (7.0)	2.0	0.6	187 (15)	769	182
A0900 RA Svc Bld	699 (1,970)	18,955	2927.8	9.2 (34)	251	26.6	-0.6 (8.2)	3.9	0.6	42 (15)	501	78
A1100 LLWSB	852 (17,886)	74,216	6023.3	0.3 (38)	35.8	7.0	0.1 (8.1)	4.1	0.8	334 (15)	3,563	752
A1200 RCA Storage	73,939 (26,286)	2,233,580	379,578.7	128.7 (37)	2,073	323.1	-0.1 (8.6)	1.8	0.6	2,162 (15)	12,389	2,864



<p>Table 2B-1 Group A Radiological Characterization Results For Affected Structures and Surfaces</p>												
	Direct Beta DPM/100 cm <sup>2</sup>			Removable Beta DPM/100 cm <sup>2</sup>			Removable Alpha DPM/100 cm <sup>2</sup>			Exposure Rate MicroR/hr		
Package	Mean (MDC)	Maximum	Std. Dev.	Mean (MDC)	Maximum	Std. Dev.	Mean (MDC)	Maximum	Std. Dev.	Mean Minimum Detectable Exp Rate (MDER)*	Maximum	Std. Dev.
A1300 Equip Hatch	27.5 (600)	720.5	255.1	4.9 (35)	19.8	7.6	-0.1 (7.8)	1.9	0.5	27.1 (15)	122.7	33.7
A1400 Pers Hatch	350.2 (2198)	6,758	1379.9	47.1 (35)	657.5	126.8	-0.2 (7.8)	1.9	0.3	47.5 (15)	180.2	41.2
A1500 Mech Pen	214.9 (661)	3,678	734.3	4.4 (38)	23.5	7.7	-0.2 (8.4)	3.9	0.6	9.4 (15)	14.0	2.6
A1600 Elec Pen	-138.0 (654)	557.1	269.7	1.9 (37)	18.2	6.9	0.0 (7.7)	1.8	0.6	12.7 (15)	14.0	1.2
A1700 Spray Bld	83,249 (24,797)	4,968,088	431,253.4	177.5 (37)	19,727	1445.2	0.0 (7.2)	2.0	0.4	1,598 (15)	9,041	2,124
A1800 Aux Feed Pump	147.5 (2,019)	1,278	422.4	2.3 (37)	36.6	11.3	-0.1 (7.7)	1.8	0.5	18.9 (15)	34.9	7.1
A1900 HV-9	130.6 (6318)	2,563	725.3	0.6 (36)	24.6	7.0	-0.1 (8.2)	1.8	0.6	90.6 (15)	182.9	45.9
A2100 RWST	3,602 (21,587)	54,719	13,158.9	2.7 (38)	72.4	13.5	0.0 (8.4)	1.8	0.7	687.5 (15)	1,078.4	374.0
A2200 BWST	7,269 (21,255)	43,189	10,833.4	7.1 (36)	73.2	16.9	-0.1 (8.2)	1.8	0.6	667.6 (15)	1,197	246.6
A2300 PWST	668 (2,780)	3,258	942.1	5.8 (32)	27.4	7.1	0.1 (8.4)	1.8	0.8	N/A	N/A	N/A
A2400 Test Tks	955.5 (1438)	4,300	1062.8	3.5 (36)	30.7	7.3	0.4 (8.2)	5.8	1.3	N/A	N/A	N/A

\* NOTE: MDER values are for the instrument in a low background area.

<p align="center"><b>Table 2B-2</b> <b>Group B</b> <b>Unaffected Structures and Surfaces, Including Structural Background Survey</b></p>												
	Direct Beta DPM/100 cm <sup>2</sup>			Removable Beta DPM/100 cm <sup>2</sup>			Removable Alpha DPM/100 cm <sup>2</sup>			Exposure Rate microR/hr		
Package	Mean (MDC)	Max	Std. Dev.	Mean (MDC)	Max	Std. Dev.	Mean (MDC)	Max	Std. Dev.	Mean Minimum Detectable Exp Rate (MDER)*	Max	Std. Dev.
B0100 Turb El 61Ft	26.7 (636)	653.7	246.9	3.5 (17)	19.1	4.8	-0.3 (7.6)	4.8	0.9	9.0 (15)	15.2	1.9
B0200 Control Rm (Old)	215.8 (616)	1054.2	384.1	4.1 (16)	25.8	5.4	-0.5 (7.6)	2.0	0.7	10.2 (15)	12.5	1.1
B0300 MCC	-91.0 (701)	552.5	299.7	1.9 (17)	11.7	4.8	-0.2 (7.3)	2.1	0.9	12.2 (15)	14.9	2.0
B0400 Fire Pmp	10.1 (610)	840.1	351.2	2.6 (32)	18.4	5.3	-0.6 (8.2)	0.7	0.4	11.2 (15)	12.8	1.6
B0500 Turb El 21Ft	62.1 (649)	8613.8	752.2	2.8 (17)	203.4	15.8	-0.4 (7.3)	2.1	0.7	8.6 (15)	17.3	2.8
B0600 Turb El 39 Ft	48.2 (603)	2031.4	332.9	2.9 (17)	30.0	6.1	-0.1 (7.3)	3.5	0.9	6.3 (15)	13.7	2.9
B0700 Svc. Bld. Non-RCA	80.0 (821)	1621.5	411.1	2.8 (32)	19.9	5.0	-0.1 (8.4)	2.4	0.7	12.5 (15)	26.0	3.5
B0800 FOSB	-82.7 (587)	451.4	286.0	5.5 (16)	19.9	6.1	-0.2 (6.7)	0.9	0.5	8.4 (15)	9.9	0.8
B0900 EDGs	-176.9 (683)	411.9	209.8	4.3 (16)	19.9	5.6	-0.1 (6.7)	0.9	0.6	10.8 (15)	13.1	1.6

<p align="center"><b>Table 2B-2</b> <b>Group B</b> <b>Unaffected Structures and Surfaces, Including Structural Background Survey</b></p>												
	Direct Beta DPM/100 cm <sup>2</sup>			Removable Beta DPM/100 cm <sup>2</sup>			Removable Alpha DPM/100 cm <sup>2</sup>			Exposure Rate microR/hr		
Package	Mean (MDC)	Max	Std. Dev.	Mean (MDC)	Max	Std. Dev.	Mean (MDC)	Max	Std. Dev.	Mean Minimum Detectable Exp Rate (MDER)*	Max	Std. Dev.
B1000 Aux Boiler	183.4 (679)	1309.7	492.6	3.4 (16)	16.5	5.9	-0.2 (6.7)	2.4	0.7	9.2 (15)	10.5	0.9
B1100 Circ Water	-333.9 (699)	672.7	300.5	1.8 (16)	11.4	4.1	0.0 (6.7)	2.4	0.9	8.5 (15)	10.8	1.3
B1200 Admin Bld	293.1 (686)	1628.2	431.9	4.3 (16)	14.8	5.1	0.0 (6.7)	2.4	0.9	13.3 (15)	15.2	1.5
B1300 WART	-146.3 (666)	1163.8	542.5	2.6 (16)	13.1	4.5	0.1 (6.7)	2.4	0.9	11.1 (15)	12.9	1.2
B1400 Info Ctr	295.3 (678)	1928.8	325.6	2.1 (16)	21.5	5.0	0.1 (6.7)	3.8	1.0	13.4 (15)	16.8	1.3
B1500 Warehse 2	96.1 (566)	539.0	212.4	0.6 (18)	19.4	5.2	-0.3 (7.3)	2.1	0.8	10.3 (15)	15.1	1.4
B1600 Trng Annex	-13.5 (657)	708.2	256.1	1.6 (18)	17.7	4.8	-0.2 (7.3)	2.1	0.8	17.8 (15)	23.8	3.5
B1700 Staff Bld	129.4 (727)	952.9	279.5	-1.0 (18)	14.4	4.5	-0.4 (7.3)	3.5	0.7	14.2 (15)	23.2	3.3
B1800 Spare Gen Bld	-39.8 (548)	341.9	176.6	0.1 (18)	9.3	4.6	-0.5 (7.3)	0.7	0.5	N/A	N/A	N/A
B1900 Bailey House	612.3 (682)	6523.7	1595.1	0.3 (18)	11.0	6.1	-0.4 (7.3)	0.7	0.6	9.4 (15)	16.1	3.6

<p>Table 2B-2 Group B Unaffected Structures and Surfaces, Including Structural Background Survey</p>												
	Direct Beta DPM/100 cm <sup>2</sup>			Removable Beta DPM/100 cm <sup>2</sup>			Removable Alpha DPM/100 cm <sup>2</sup>			Exposure Rate microR/hr		
Package	Mean (MDC)	Max	Std. Dev.	Mean (MDC)	Max	Std. Dev.	Mean (MDC)	Max	Std. Dev.	Mean Minimum Detectable Exp Rate (MDER)*	Max	Std. Dev.
B2000 Bailey Barn	-96.6 (592)	306.5	187.3	1.1 (18)	9.3	4.6	-0.4 (7.3)	0.7	0.6	9.2 (15)	10.6	0.8
B2100 Lube Oil Storage	8.7 (630)	610.4	240.7	0.2 (18)	7.6	4.3	-0.5 (7.3)	0.7	0.6	8.8 (15)	10.9	1.8
B2200 Cold Shop	139.4 (604)	762.3	317.9	0.6 (18)	7.6	4.0	-0.5 (7.3)	0.7	0.5	8.0 (15)	9.0	0.9
B2300 Cable Vault	-23.4 (632)	275.3	195.1	0.5 (18)	21.3	5.0	-0.3 (6.9)	2.3	0.6	13.8 (15)	17.1	1.9
B2400 Staff Tunnel	19.2 (779)	575.6	359.6	3.8 (18)	18.0	6.7	-0.1 (6.9)	3.7	0.9	20.3 (15)	24.2	2.3

\* NOTE: MDER values are for the instrument in a low background area.

<p><b>Table 2B-3</b> <b>Group C</b> <b>Radiological Characterization Results For Affected Systems</b></p>													
	Direct Beta DPM/100 cm <sup>2</sup>			Removable Beta DPM/100 cm <sup>2</sup>			Removable Alpha DPM/100 cm <sup>2</sup>			Exposure Rate microR/hr			Tritium DPM/ 100 cm <sup>2</sup>
Package	Mean (MDC)	Max	Std. Dev	Mean (MDC)	Max	Std. Dev.	Mean (MDC)	Max	Std. Dev.	Mean Minimum Detectable Exp Rate (MDER)*	Max	Std. Dev.	Mean
C0100 PASS	N/A	N/A	N/A	77,858 (5000)	300,000	126,236	1.5 (8.4)	8.0	3.7	1386 (15)	4161	1422.9	61.1 (39)
C0200 Waste Solid.	N/A	N/A	N/A	2344 (34)	4073	2069.9	-0.3 (8.4)	-0.3	0.0	23,333 (15)	219,340	53,199	399.9 (39)
C0300 Contain. Spray	N/A	N/A	N/A	25,185 (34)	39,530	14,366.8	11.5 (8.4)	24.7	11.5	2593 (15)	22,862	4192	18.4 (39)
C0400 ECCS	N/A	N/A	N/A	70,933 (5000)	200,000	111,776	3.3 (8.4)	5.9	3.0	4416 (15)	34,960	6025	1377.8 (139)
C0500 RHR	N/A	N/A	N/A	76,000 (5000)	180,000	91,476.8	N/A	N/A	N/A	4882 (15)	15,772	4112	23,617 (139)
C0600 Pri. Vent & Drains	N/A	N/A	N/A	50,585 (5000)	140,000	77,438	-0.2 (8.4)	0.0	0.2	165,583 (15)	1,326,311	325,892	548 (39)
C0700 SFP Cooling	N/A	N/A	N/A	13,693 (5000)	20,000	6466.2	3.4 (8.4)	10.1	5.8	829,672 (15)	16,945,540	2,924,669	31.0 (39)
C0800 Waste Gas	N/A	N/A	N/A	3251 (34)	6470	2854.0	-0.3 (8.4)	-0.3	0.0	3295 (15)	23,554	4,999.5	5825 (39)
C0900 Pzr.	N/A	N/A	N/A	213,333 (5000)	360,000	128,582	N/A	N/A	N/A	41,636 (15)	376,269	59,187	82,468 (139)
C1100 RCS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	53,580 (15)	181,323	34,275	N/A

<p>Table 2B-3 Group C Radiological Characterization Results For Affected Systems</p>													
	Direct Beta DPM/100 cm <sup>2</sup>			Removable Beta DPM/100 cm <sup>2</sup>			Removable Alpha DPM/100 cm <sup>2</sup>			Exposure Rate microR/hr			Tritium DPM/ 100 cm <sup>2</sup>
Package	Mean (MDC)	Max	Std. Dev	Mean (MDC)	Max	Std. Dev.	Mean (MDC)	Max	Std. Dev.	Mean Minimum Detectable Exp Rate (MDER)*	Max	Std. Dev.	Mean
C1200 Boron Recovery	N/A	N/A	N/A	53,766 (5000)	160,000	92,001.4	-0.2 (8.4)	0.0	0.2	1283 (15)	13,023	2078	19,515 (39)
C1300 CVCS	1907	3924.8	2074.1	29,197 (1316)	112,370	47,511.3	8.8 (7.8)	34.9	14.8	41,446 (15)	884,946	127,708	1057 (139)
C1400 Liq. Waste	N/A	N/A	N/A	1078 (35)	1403	289.4	1.2 (7.8)	3.9	2.4	91,689 (15)	935,068	166,593	1187 (39)
C1500 PAB Drains	N/A	N/A	N/A	1895 (35)	6002	2409.7	0.5 (7.8)	1.9	1.1	2059 (15)	10,306	2309	128.4 (38)
C1600 PAB Vent	5275 (1144)	16,837	6185.7	52.8 (35)	194	72.0	-0.1 (7.8)	1.9	0.6	492.4 (15)	3546	1007	-17.6 (38)
C1800 Contain. Vent	448,954 (15,606)	540,758	77,163.2	16,768 (5000)	80,000	35,348.1	1.1 (7.8)	3.9	1.8	802.4 (15)	2275	653	-3.4 (38)
C1900 S/Gs	N/A	N/A	N/A	266,667 (5000)	500,000	202,320	N/A	N/A	N/A	17,071 (15)	82,025	21,980	398.0 (139)

\* NOTE: MDER values are for the instrument in a low background area.

Table 2B-4 -Group D Unaffected Systems												
	Direct Beta DPM/100 cm <sup>2</sup>			Removable Beta DPM/100 cm <sup>2</sup>			Removable Alpha DPM/100 cm <sup>2</sup>			Exposure Rate microR/hr		
Package	Mean (MDC)	Max	Std. Dev.	Mean (MDC)	Max	Std. Dev.	Mean (MDC)	Max	Std. Dev.	Mean Minimum Detectable Exp Rate (MDER) *	Max	Std. Dev.
D0100 Condens.	66.7	2184.5	425.2	-0.5	14.6	5.1	-0.3	2.3	0.7	1.9 (15)	2.1	0.1
D0200 Water Treat.	1250.8 (1937)	26,046.3	4898.1	38.1 (16)	945.1	162.8	13.6 (7.6)	362.2	61.9	12.6 (15)	44.2	17.7
D0300 Potable Water	526.2 (1089)	2638.6	767.7	6.7 (16)	29.2	6.9	0.4 (7.6)	9.1	2.3	4.5 (15)	7.1	1.6
D0400 Sewer	384.8 (1088)	5657.1	1051.5	3.2 (36)	32.2	8.9	0.0 (8.2)	1.9	0.6	11.3 (15)	16.2	4.3
D0500 Circ Water	162.0 (587)	811.8	295.1	3.1 (15)	14.7	4.2	-0.1 (6.9)	5.1	0.9	3.7 (15)	17.2	5.1
D0600 Svc Water	38.0 (1687)	1013.9	347.9	197.5 (37)	3133.7	658.5	-0.2 (8.6)	1.8	0.5	N/A	N/A	N/A
D0700 Fire Prot.	-35.6 (1257)	1114.7	240.2	2.4 (17)	20.6	5.2	0.2 (6)	2.5	0.9	N/A	N/A	N/A
D0800 Lube Oil	66.0 (1681)	723.4	253.6	2.5 (17)	22.3	6.1	0.1 (6)	2.5	0.7	6.0 (15)	12.3	5.5
D0900 Comp. Air	3677.5 (6324)	104,589	14,456.3	27.0 (17)	685.2	95.1	0.4 (6)	6.8	1.4	N/A	N/A	N/A
D1000 Aux Boiler	446.0 (2606)	2723.9	730.5	12.3 (17)	114.8	21.8	0.0 (6)	2.5	0.8	7.1 (15)	20.1	5.3
D1100 S/G	270.8 (1347)	2664.1	1067.4	9.2 (17)	47.5	11.1	0.3 (6)	2.5	1.0	35.0 (15)	66.8	44.9

Table 2B-4 -Group D Unaffected Systems												
	Direct Beta DPM/100 cm <sup>2</sup>			Removable Beta DPM/100 cm <sup>2</sup>			Removable Alpha DPM/100 cm <sup>2</sup>			Exposure Rate microR/hr		
Package	Mean (MDC)	Max	Std. Dev.	Mean (MDC)	Max	Std. Dev.	Mean (MDC)	Max	Std. Dev.	Mean Minimum Detectable Exp Rate (MDER) *	Max	Std. Dev.
D1200 Main Steam	-9.2 (1002)	4598.7	649.0	0.8 (36)	59.6	9.3	-0.3 (8.2)	2.2	0.7	N/A	N/A	N/A
D1300 Aux Steam	667.3 (2382)	11,786.6	1963.4	1.9 (36)	19.4	6.5	0.0 (8.2)	2.0	0.5	162.8 (15)	435.1	218.9
D1400 Turb Control	-38.3 (839)	416.5	189.7	-0.9 (19)	20.9	6.3	-0.4 (7.1)	0.8	0.5	0.8 (15)	1.6	0.4
D1500 Steam Dump	-216.5 (677)	64.1	139.9	-0.8 (19)	10.8	4.1	-0.5 (7.1)	0.8	0.5	N/A	N/A	N/A
D1600 Main Feed	-0.3 (640)	453.9	160.8	-1.2 (19)	24.2	6.3	-0.4 (7.1)	2.2	0.6	2.0 (15)	5.4	2.2
D1700 EFW	-136.5 (2414)	851.3	347.6	0.9 (18)	21.0	5.3	-0.3 (7.1)	3.6	0.8	N/A	N/A	N/A
D1800 Htr. Drain, Extract	42.4 (1182)	1864.3	323.3	-2.7 (19)	9.1	3.8	-0.4 (7.1)	2.2	0.6	0.9 (15)	1.3	0.4
D1900 Comp Cooling	1168.0 (4385)	21,644.3	6616.3	5.2 (36)	38.0	10.7	-0.1 (7.2)	2.0	0.3	10.1 (15)	12.8	2.0
D2000 Vac Prim	24.8 (1256)	672.1	257.8	1.6 (18)	14.2	4.8	-0.3 (7.1)	2.2	0.8	N/A	N/A	N/A
D2100 Amertap	107.5 (1200)	1880.2	507.5	2.2 (18)	15.9	5.4	0.1 (7.1)	3.6	1.1	N/A	N/A	N/A
D2200 Sealing Steam	23.3 (1067)	582.0	237.8	0.2 (18)	10.9	4.2	-0.5 (7.1)	0.8	0.5	N/A	N/A	N/A



Table 2B-4 -Group D Unaffected Systems												
	Direct Beta DPM/100 cm <sup>2</sup>			Removable Beta DPM/100 cm <sup>2</sup>			Removable Alpha DPM/100 cm <sup>2</sup>			Exposure Rate microR/hr		
Package	Mean (MDC)	Max	Std. Dev.	Mean (MDC)	Max	Std. Dev.	Mean (MDC)	Max	Std. Dev.	Mean Minimum Detectable Exp Rate (MDER) *	Max	Std. Dev.
D2300 Aux DG	31.7 (645)	535.3	210.8	3.1 (36)	31.8	9.3	0.1 (7.2)	2.0	0.7	N/A	N/A	N/A
D2400 Chem Sample	35.2 (1617)	645.5	251.2	307.2 (35)	4861.3	995.8	0.3 (7.8)	6.0	1.4	N/A	N/A	N/A
D2500 HP Drain	132.2 (1048)	594.8	260.3	-0.1 (18)	7.5	4.7	-0.4 (7.1)	0.8	0.6	N/A	N/A	N/A
D2600 Envir	336.6 (535)	1257.1	400.1	3.7 (14)	12.9	3.9	0.6 (6.9)	3.9	1.3	N/A	N/A	N/A
D2700 Admin HVAC	74.3 (789)	643.3	276.3	5.2 (18)	32.8	8.5	0.3 (7.1)	2.2	1.1	8.0 (15)	8.0	0.0
D2800 Info Ctr Hvac	156.2 (702)	627.8	256.9	0.6 (18)	10.9	4.7	-0.5 (7.1)	0.8	0.5	N/A	N/A	N/A
D2900 Turb HVAC	142.4 (577)	445.4	161.5	4.6 (14)	33.1	5.9	0.3 (6.9)	3.9	0.9	N/A	N/A	N/A
D3000 Staff HVAC	262.9 (779)	1286.3	366.0	2.2 (18)	15.9	6.0	-0.1 (7.1)	2.2	0.9	N/A	N/A	N/A
D3100 Svc HVAC	5346.8 (1082)	87,565.8	19,067.0	80.0 (14)	1445.0	247.1	0.6 (8.5)	5.9	1.3	22.4 (15)	51.4	17.4
D3200 H2/N2	12,037.3 (3059)	125,317	36,307.5	104.5 (14)	828.9	245.4	0.6 (8.5)	9.9	2.3	N/A	N/A	N/A
D3300 Turb Sumps	433.1 (1091)	5800.9	1166.9	8.1 (32)	33.6	9.0	0.0 (8.4)	1.8	0.8	10.8 (15)	15.9	4.9

Table 2B-4 -Group D Unaffected Systems												
Package	Direct Beta DPM/100 cm <sup>2</sup>			Removable Beta DPM/100 cm <sup>2</sup>			Removable Alpha DPM/100 cm <sup>2</sup>			Exposure Rate microR/hr		
	Mean (MDC)	Max	Std. Dev.	Mean (MDC)	Max	Std. Dev.	Mean (MDC)	Max	Std. Dev.	Mean Minimum Detectable Exp Rate (MDER) *	Max	Std. Dev.
D3400 LLWSB	457.0 (992)	3099.3	1300.0	7.1 (32)	27.4	8.7	0.1 (8.4)	6.0	1.3	N/A	N/A	N/A

\* NOTE: MDER values are for the instrument in a low background area.

Table 2B-5 Group R Radiological Characterization Results For Affected and Unaffected Environs												
Package										Exposure Rate microR/hr		
	# Sample s	# Positive Co-60	Mean Co-60 pCi/g	Max Co-60 pCi/g	# Positive Cs-137	Mean Cs-137 pCi/g	Max Cs-137 pCi/g			Mean	Maximum	Std. Dev.
R0100 RA Yard West	58	23	0.62	3.29	55	10.99	156.0	N/A	N/A	N/A	N/A	N/A
R0200 Yard East	35	12	0.28	1.94	33	4.88	133.0	N/A	N/A	N/A	N/A	N/A
R0300 Roof Drains	7	4	4.09	11.2	6	0.33	0.53	N/A	N/A	N/A	N/A	N/A
R0400 Shoreline	27	1	0.08	0.08	27	0.34	0.98	N/A	N/A	N/A	N/A	N/A
R0500 Bailey Pt.	45	0	0	0	44	0.38	1.09	N/A	N/A	13.27	19.83	1.49
R0600 Ball Field	32	0	0	0	3	0.04	0.06	N/A	N/A	11.92	13.68	0.63

Table 2B-5 Group R Radiological Characterization Results For Affected and Unaffected Environs												
Package										Exposure Rate microR/hr		
	# Sample s	# Positive Co-60	Mean Co-60 pCi/g	Max Co-60 pCi/g	# Positive Cs-137	Mean Cs-137 pCi/g	Max Cs-137 pCi/g			Mean	Maximum	Std. Dev.
R0700 Constr. Debris	31	0	0	0	2	0.05	0.06	N/A	N/A	11.99	14.52	1.05
R0800 Admin. Parking	30	0	0	0	26	0.26	0.83	N/A	N/A	17.9	33.87	4.2
R0900 BOP	36	6	1.22	5.11	24	11.06	85.6	N/A	N/A	25.85	77.71	16.8
R1000 Foxbird Is	73	3	0.22	0.38	43	0.43	1.63	N/A	N/A	11.48	42.76	4.97
R1100 Roof Drains	15	0	0	0	3	0.07	0.09	N/A	N/A	N/A	N/A	N/A
R1200 LLWSB Yard	30	0	0	0	5	0.10	0.13	N/A	N/A	N/A	N/A	N/A
R1300 ISFSI	30	0	0	0	5	0.12	0.28	N/A	N/A	12.92	31.2	3.68
R1400 Shorelines	30	0	0	0	30	0.20	0.35	N/A	N/A	N/A	N/A	N/A
R1500 Ash Pit Rubble	30	0	0	0	9	0.07	0.21	N/A	N/A	11.34	12.63	0.63
R1600 Eaton Farm Land	60	0	0	0	59	0.045	1.43	N/A	N/A	12.07	17.8	2.06
R1700 Land North of Ferry Rd	60	0	0	0	50	0.39	1.55	N/A	N/A	9.65	13.74	1.56

<p><b>Table 2B-5</b>  <b>Group R</b>  <b>Radiological Characterization Results For Affected and Unaffected Environs</b></p>												
Package										Exposure Rate microR/hr		
	# Sample s	# Positive Co-60	Mean Co-60 pCi/g	Max Co-60 pCi/g	# Positive Cs-137	Mean Cs-137 pCi/g	Max Cs-137 pCi/g			Mean	Maximum	Std. Dev.
R1800 Bailey Farm Land	31	0	0	0	22	0.27	0.76	N/A	N/A	10.63	14.57	1.31
R1900 Bailey Cove	14	0	0	0	14	0.27	0.37	N/A	N/A	N/A	N/A	N/A
R2000 Diffuser	5	2	0.1	0.12	4	0.10	0.13	N/A	N/A	N/A	N/A	N/A
R2100 Warehse Yard	30	0	0	0	4	0.13	0.33	N/A	N/A	8.41	10.62	1.33
R2200 Backgrnd*	62	0	0	0	62	0.35	1.4	N/A	N/A	11.37	13.59	1.26
R2300 SFP Substation	16	1	0.14	0.14	15	0.35	0.81	N/A	N/A	26.14	29.4	1.46
R2400 IT Duplicates	44	0	0	0	9	0.48	1.62	N/A	N/A	N/A	N/A	N/A

\* Includes twelve marine sediment samples taken the New Meadows River and the Damariscotta River.

Table 2B-6 R2500 Investigation Package							
Package	# Samples	# Positive Co-60	Mean Co-60 pCi/g	Max Co-60 pCi/g	# Positive Cs-137	Mean Cs-137 pCi/g	Max Cs-137 pCi/g
R0500 Bailey Pt	8	3	11,218.5	33,600.0	7	0.13	0.21
R0600 Ball Field	15	0	0	0	5	0.16	0.29
R0700 Construction Debris	40	0	0	0	3	0.04	0.06
R0800 Admin Parking Lot	15	0	0	0	14	0.17	0.33
R1000 Foxbird Is	10	0	0	0	7	0.13	0.21
R1300 ISFSI	10	2	0.43*	0.45*	4	0.07	0.12
R1600 Eaton Farm Land	5	0	0	0	2	0.27	0.29
R1800 Bailey Farm Land	20	0	0	0	13	0.10	0.15

\* Activity consisted, in part, of discrete particles

Table 2B-7 R2501 Investigation Package							
Package	# Samples	# Positive	Mean Co-60 pCi/g	Max Co-60 pCi/g	# Positive Cs-137	Mean Cs-137 pCi/g	Max Cs-137 pCi/g
R0900 BOP	41	16	0.12	0.49	41	17.1	145
R1000 Foxbird Is.	26	2	0.08	0.11	24	2.53	10.0
R2500 Contractors Parking	27	0*	0*	0*	4	0.20	0.31

\*0 indicates less than MDC where MDC is  $\leq 0.1$  pCi/g for soil

**Table 2B-8**  
**Radiological Characterization Water Sample Results For Affected and Unaffected**  
**Environs, Including Environs Background Study**

Package	Well/Catch Basin Identification	Tritium Activity pCi/L	Plant Derived Gamma Activity ?
R0100	203	1198	No
	205	928	No
	206	541	No
	BK-1	4023	No
	Chromate Well	914	No
	CTMT Foundation Sump	6812	No

Average	2403
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Package	Well/Catch Basin Identification	Tritium Activity pCi/L	Plant Derived Gamma Activity ?
R0200	202	622	No
	204	441	No
	MW100	788	No

Average	617
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Package	Well/Catch Basin Identification	Tritium Activity pCi/L	Plant Derived Gamma Activity ?
R0300	6A	2005	No
	7A	3266	No
	7B	978	No
	7E	2712	No
	Outfall #6	716	No

Average	1935
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Package	Well/Catch Basin Identification	Tritium Activity pCi/L	Plant Derived Gamma Activity ?
<b>R1100</b>	9A	833	No
	10A	815	No
	11A	581	No

Average	743
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Package	Well/Catch Basin Identification	Tritium Activity pCi/L	MDA pCi/L	Plant Derived Gamma Activity ?
<b>R2200</b>	Eaton Farm Well	685	743	No
	Bailey Farm Well	-1689	3126	No
	Days Ferry (private well)	1220	2255	No

Average	635	2042
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Package	Well/Catch Basin Identification	Tritium Activity pCi/L	Plant Derived Gamma Activity ?
<b>R2400</b>	North Transformer Sump	599	No
	Main Transformer Sump	842	No
	Groundwater Sump Edgecomb	756	No

Average	733
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## **ATTACHMENT 2C**

### **Summary of Continued Characterization Data**

<b>Table 2C-1 Group C Continued Characterization Results For Systems and Soils</b>											
Package	Direct Beta DPM/100 cm <sup>2</sup>			Isotopic Analysis Of Internals Co-60 (pCi/g)				Isotopic Analysis Of System Internals, Cs-137 (pCi/g)			
	Mean (MDC)	Max	Std. Dev.	# Positives/ #Measurements	Mean	Max	Std. Dev.	# Positives/ #Measurements	Mean	Max	Std. Dev.
CD0100 Condensate	764 (2351)	4923	1403	2/4	358	715	506	0/4	<MDC	<MDC	N/A
CD0200 Water Treatment	499 (2351)	1923	728	0/4	<MDC	<MDC	N/A	0/4	<MDC	<MDC	N/A
CD0600 Svc. Water	-6819 (5329)	- 3161	872	3/3	2.92	5.44	2.31	0/3	<MDC	<MDC	N/A
CD1900 SCC	106 (2086)	1303	53	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CD1900 PCC	3780 (2351)	1331 0	3676	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Package				Soil Isotopic Analysis, Co-60 (pCi/g)				Soil Isotopic Analysis, Cs-137 (pCi/g)			
				#Positives/ #Samples	Mean	Max	Std. Dev.	#Positives/ # Samples	Mean	Max	Std. Dev.
CR0200 Fuel Is. Pagoda	N/A	N/A	N/A	0/25	<MDC	<MDC	N/A	12/25	0.19	0.32	0.09
CR0500 Bailey Point	N/A	N/A	N/A	0/11	<MDC	<MDC	N/A	4/11	0.14	0.21	0.06
CR1000 Foxbird Is.	N/A	N/A	N/A	1/36	0.05	0.05	N/A	23/36	1.03	4.37	1.23
CR1300 Contr. Prk. Lot	N/A	N/A	N/A	0/16	<MDC	<MDC	N/A	0/16	<MDC	<MDC	N/A

MDCs ranged from: 0.1 - 0.4 pCi/g for soil samples  
30 - 80 pCi/g for valve disks  
30 - 4- pCi/smear for smear samples  
0.02 - 0.2 pCi/g for pipe debris

Table 2C-2 Continued Characterization Results for Concrete Core Activity							
Concrete Core Samples (geometry corrected except as noted (1))							
Sample #	Net CPM 43-68 (2)	Co-60 pCi/g	Cs-134 pCi/g	Cs-137 pCi/g	Eu-152 pCi/g	Eu-154 pCi/g	Area
1-1A	49900	114	11	2038			Ctmt-2'
1-2A	132000	2545	125	5566			Ctmt-2'
1-3A	29800	354	9	307			Ctmt-2'
1-4A	82400	50	27	5616			Ctmt-2'
2-1A	1460	6	0.4	11			Ctmt 20'
2-2A	1230	3	1	16			Ctmt 20'
3-1A (1)	2920	190	39	172	285		Ctmt-32'
3-2A (1)	13300	307	37	359	290	35	Ctmt-32'
3-3A (1)	2460	157	28	36	280	33	Ctmt-32'
4-1A	1270	1	0.4	14			Ctmt 46'
4-2A	18700	8	6	388			Ctmt 46'
4-3A	1960	3	1	35			Ctmt 46'
4-4A	2190	8		18			Ctmt 46'
4-5A	2920	6	0.6	29			Ctmt 46'
5-1A	2940	6	0.2	59			RCA 21'
5-2A	720	1		106			RCA 21'
5-3A	240	1		11			RCA 21'
5-4A	130	1.7		18			RCA 21'
5-5A	70	1		22			RCA 21'
5-6A	0	0		0			RCA 21'
5-7A	1090	37		63			RCA 21'
6-1A	18900	208	8	1030			PAB 11'
6-2A	130	0		4			PAB 11'
6-3A	1620	0		23			PAB 11'

Table 2C-2 Continued Characterization Results for Concrete Core Activity							
Concrete Core Samples (geometry corrected except as noted (1))							
Sample #	Net CPM 43-68 (2)	Co-60 pCi/g	Cs-134 pCi/g	Cs-137 pCi/g	Eu-152 pCi/g	Eu-154 pCi/g	Area
6-4A	0	0.4		2			PAB 11'
6-5A	0	0		0			PAB 11'
6-6A	0	0		0			PAB 11'
7-1A	630	1		7			PAB 21'
7-2A	0	0		0			PAB 21'
8-1A	410	0.3		13			Spray21'
8-2A	29610	35		809			Spray12'
8-3A	4380	4		62			Spray12'
8-4A	144000	152	3	4508			Spray12'
9-1A	190	2		38			Spray 4'
9-2A	340	2		3			Spray 4'
9-3A	110	0		2			Spray 4'
9-4A	140	6		6			Spray-6'
10-1A	40	0		4			Fuel 21'
10-2A	530	1		575			Fuel 21'
10-3A	550	2		14.7			Fuel 21'
10-4A	8690	156		1186			Fuel 21'
11-1A	2200	0		64			Fuel 31'
11-2A	1380	0		20			Fuel 31'
12-1A	54426	935	9	636			Cntmt O/A Trench
12-2A	72326	931	9	535			Cntmt O/A Trench
12-3A	53151	374	22	3280			Cntmt El-2'
12-4A	12651	66	10	1179			Cntmt El-2'

<b>Table 2C-2</b> <b>Continued Characterization Results for Concrete Core Activity</b>							
<b>Concrete Core Samples</b> (geometry corrected except as noted (1))							
Sample #	Net CPM 43-68 (2)	Co-60 pCi/g	Cs-134 pCi/g	Cs-137 pCi/g	Eu-152 pCi/g	Eu-154 pCi/g	Area
12-5A	143651	664	56	11914			Cntmt El-2'
13-1A	1193	7		61			PAB El-11'
13-2A	14383	86	10	192			PAB El-11'
13-3A	5273	52	2	47			PAB El-11'

(1) Activation Samples (not geometry corrected)

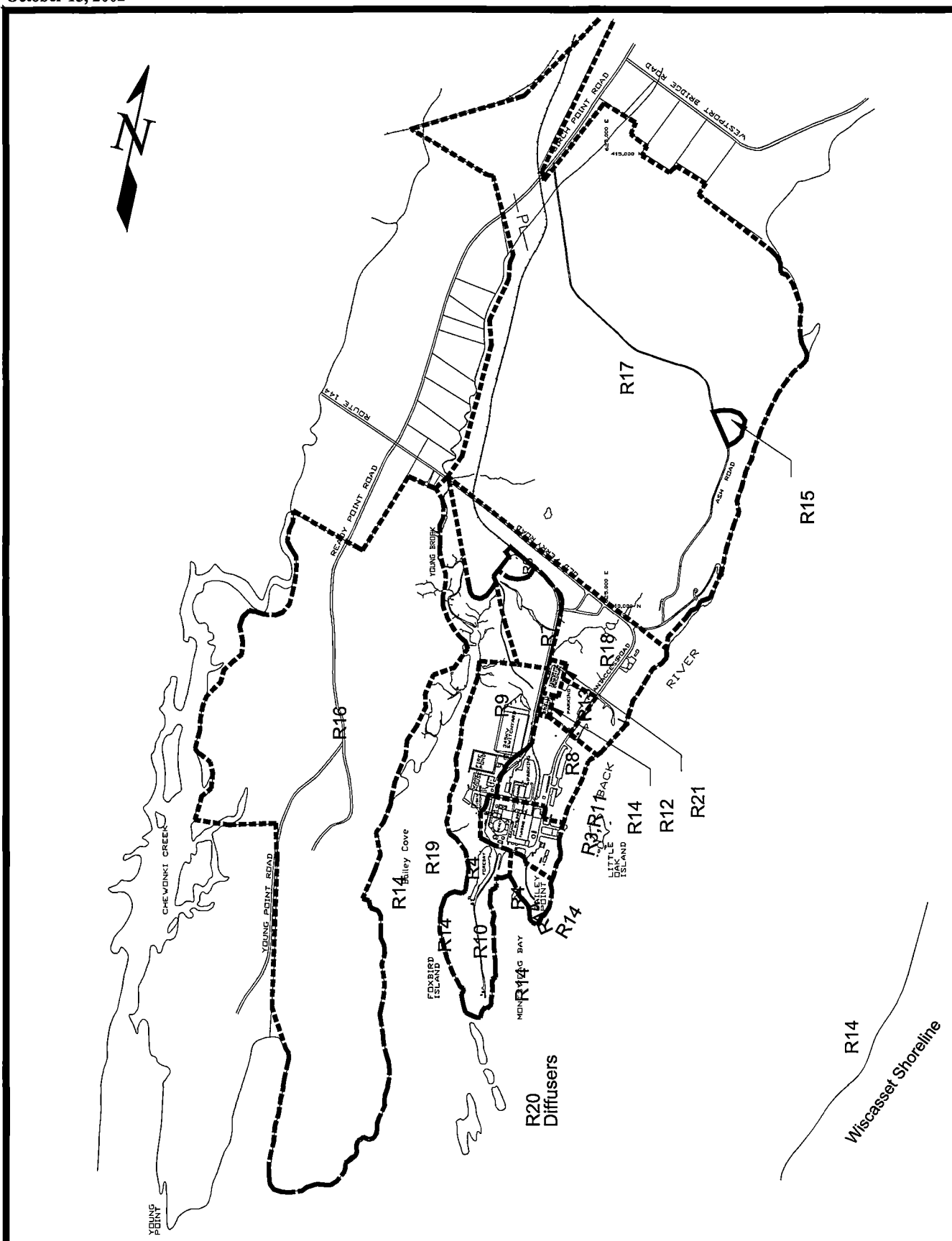
(2) Net Count Rate. For additional discussion, see Attachment 2G.

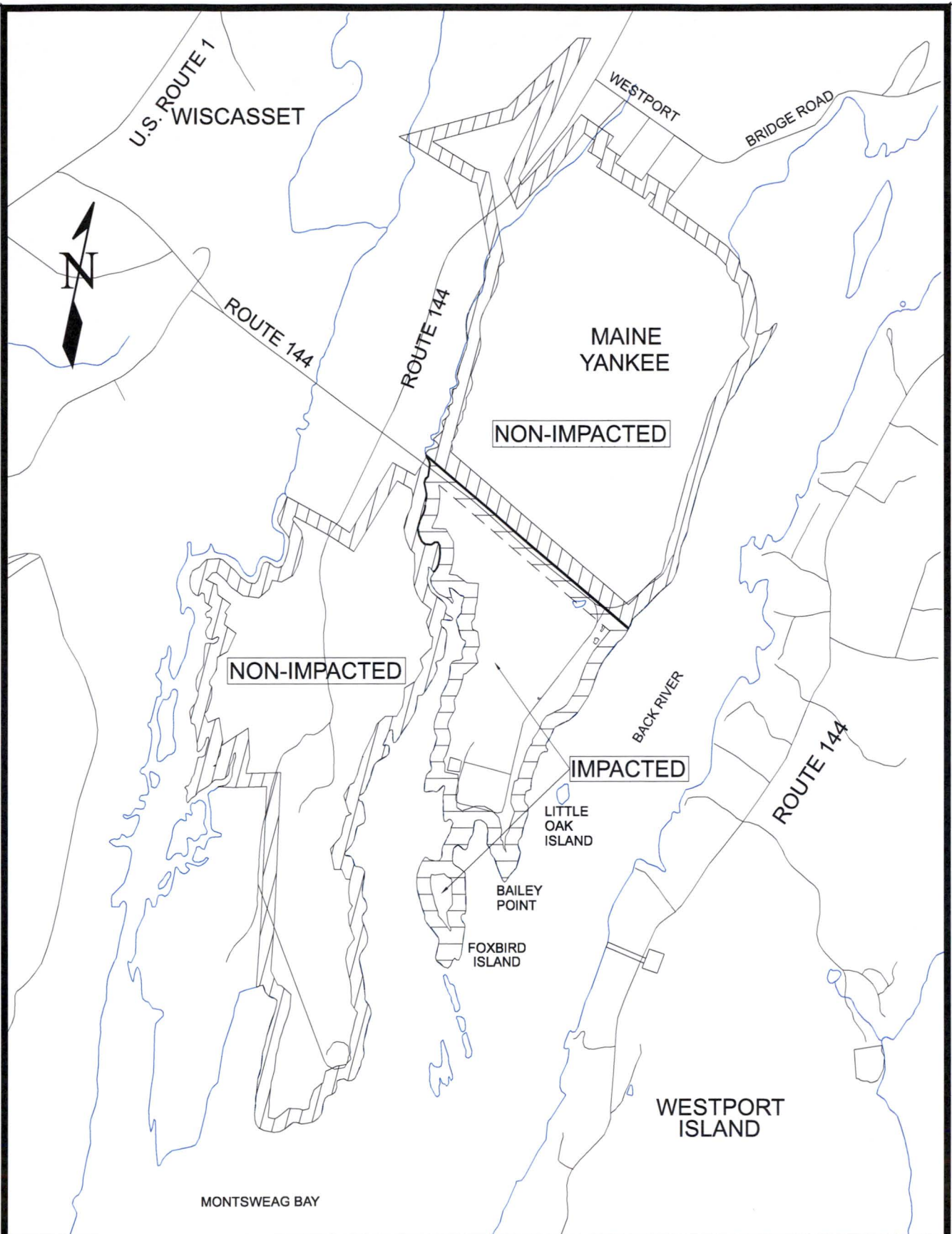
<b>Table 2C-3</b> <b>Continued Characterization Results for Water and Sediment Samples</b>	
CTMT Foundation Sump	H-3: 900 pCi/L  Gamma Spec and HTDs: No detectable Activity
Reflecting Pond	H-3: 600 to 960 pCi/L Gamma Spec: No Detectable Activity with 2E-9 µCi/ml MDA
Forebay Sediment Composite (1)	Fe-55: 13.6 pCi/g Ni-63: 8.9 pCi/g Co-60: 31.7 pCi/g Sb-125: 0.4 pCi/g Cs-137: 1.2 pCi/g

(1) Results are from the 2000 composite forebay sediment sample. For additional information, see Attachment 2H regarding forebay and diffuser characterization.

**ATTACHMENT 2D**

**Maine Yankee Site Characterization**  
**Locations of Radiological Survey Packages**





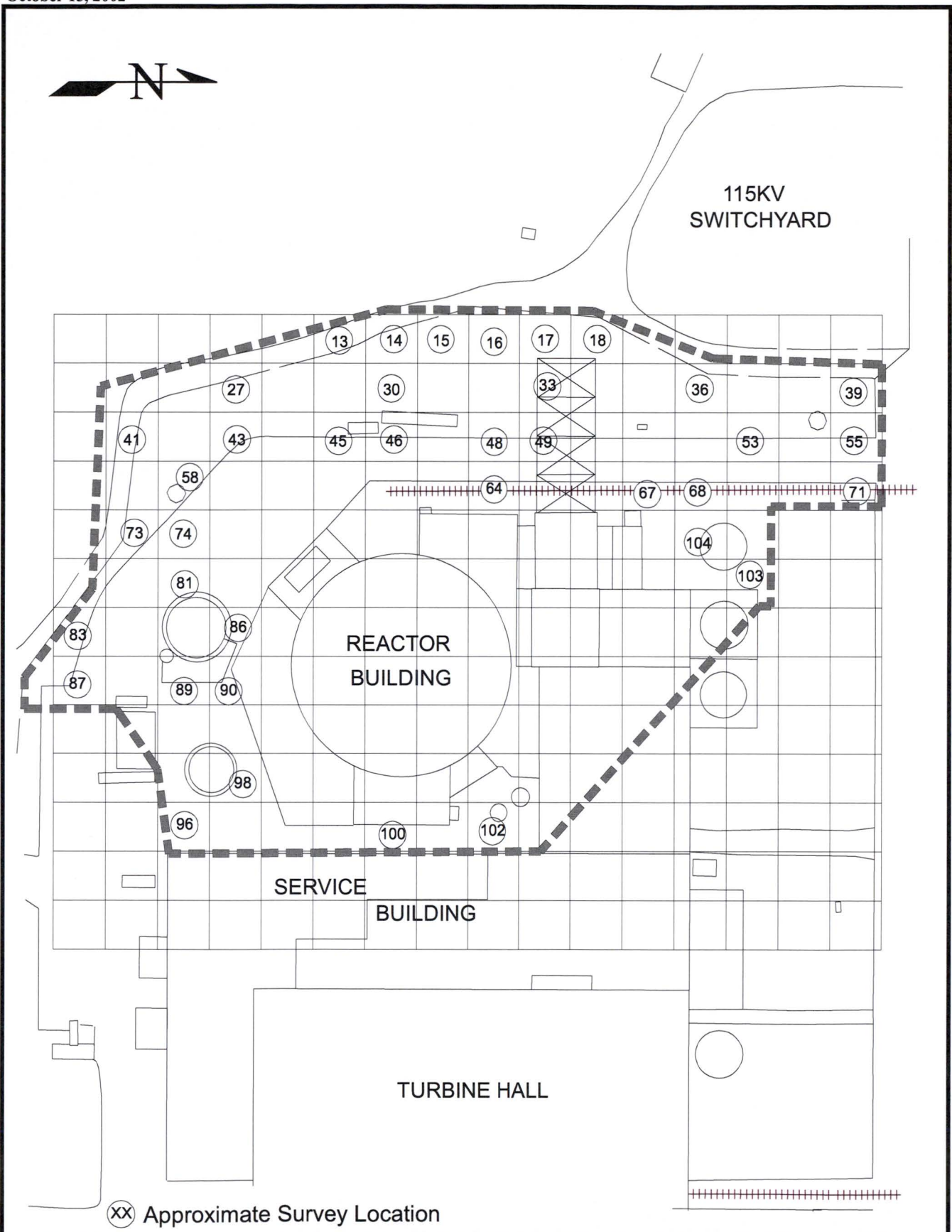


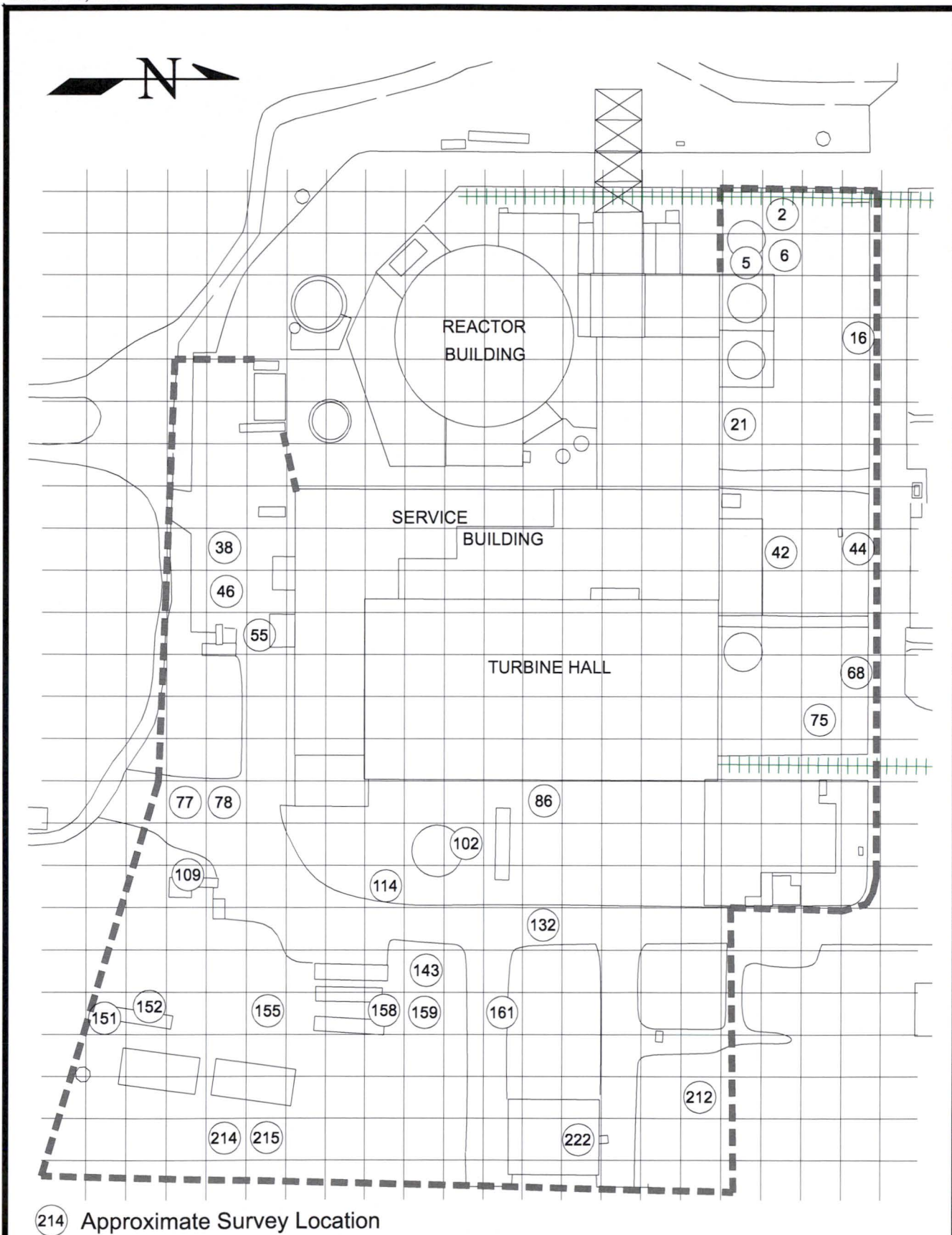
**MYAPC License Termination Plan**  
**Revision 3**  
**October 15, 2002**

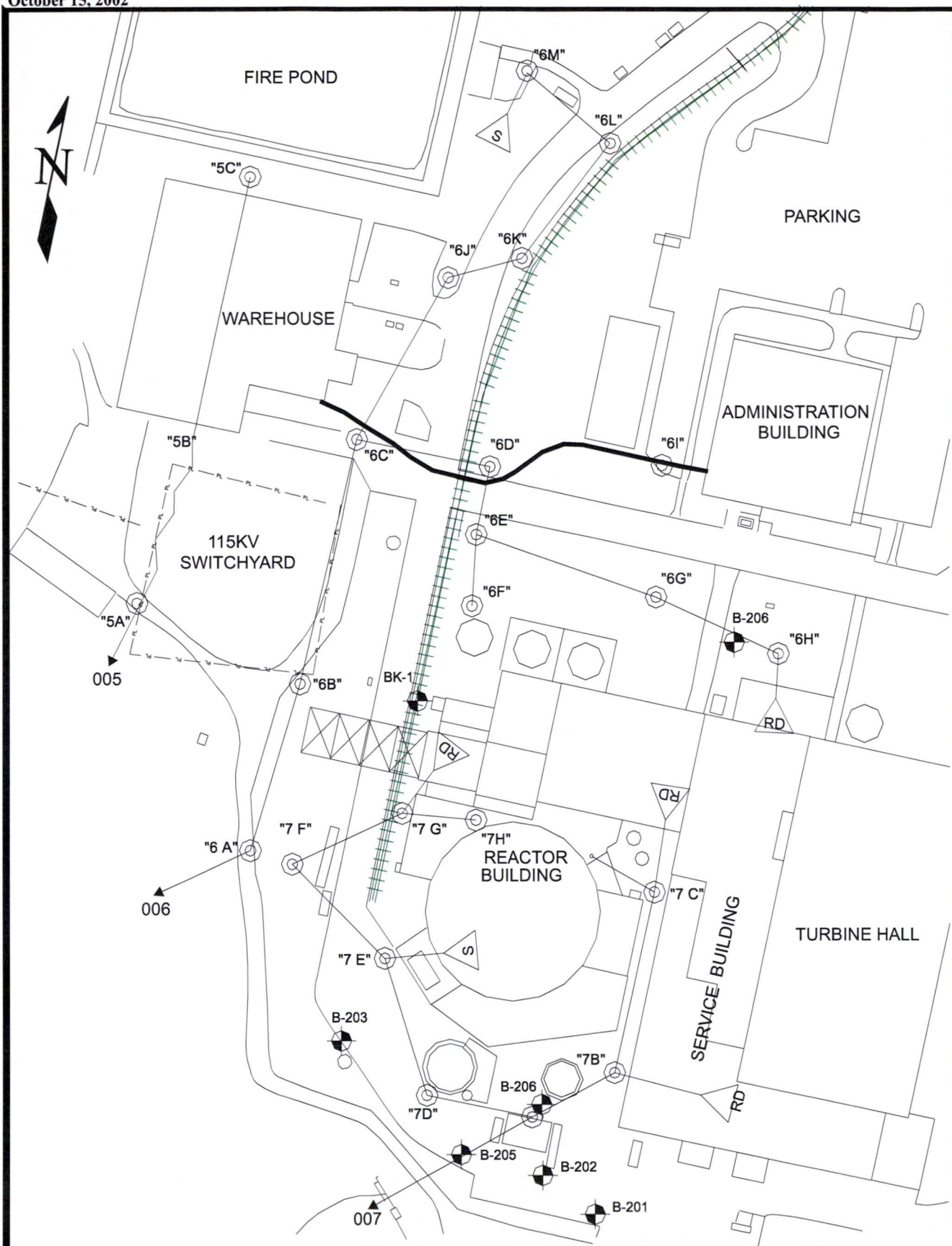
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## ATTACHMENT 2E

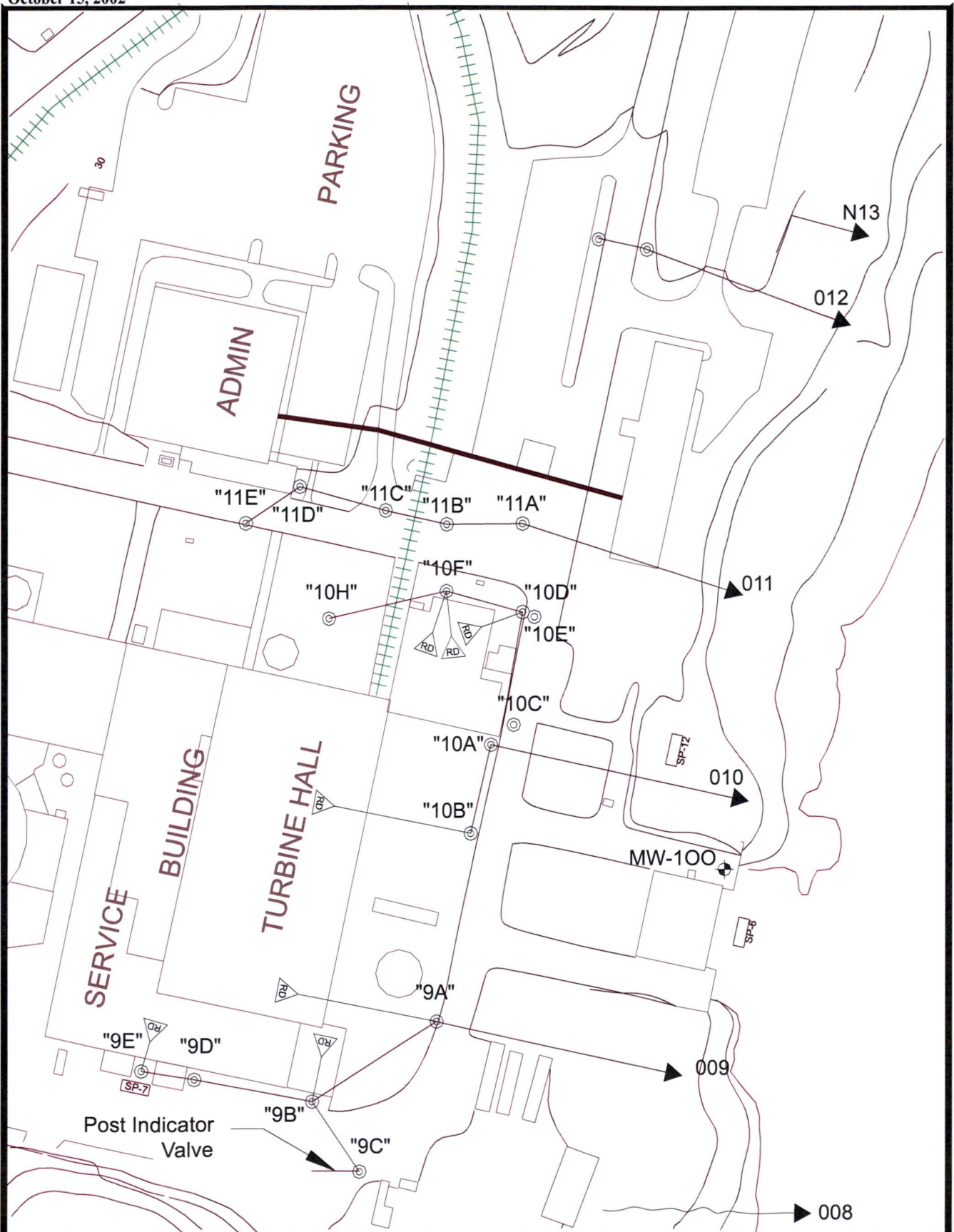
### Site and Survey Area Maps

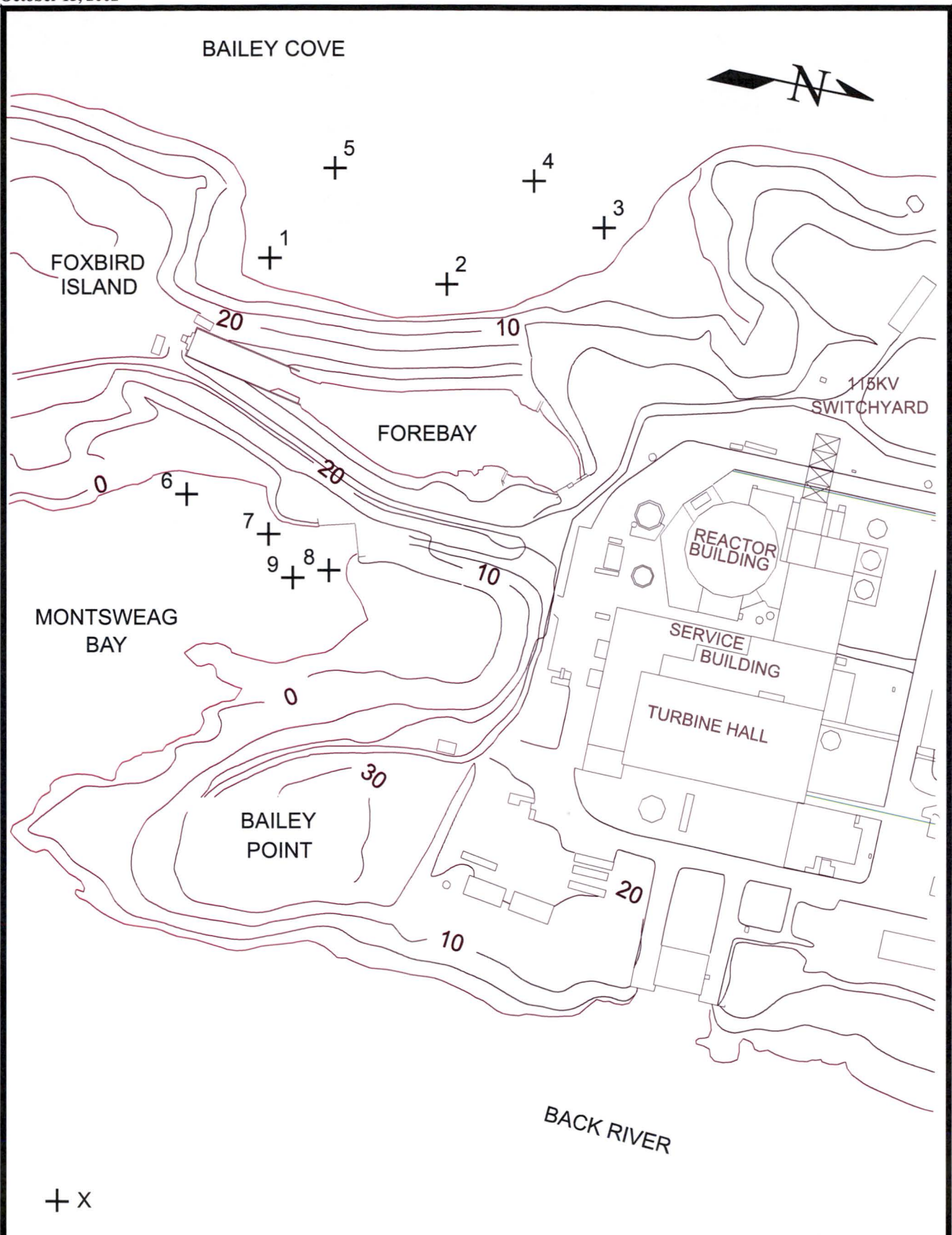


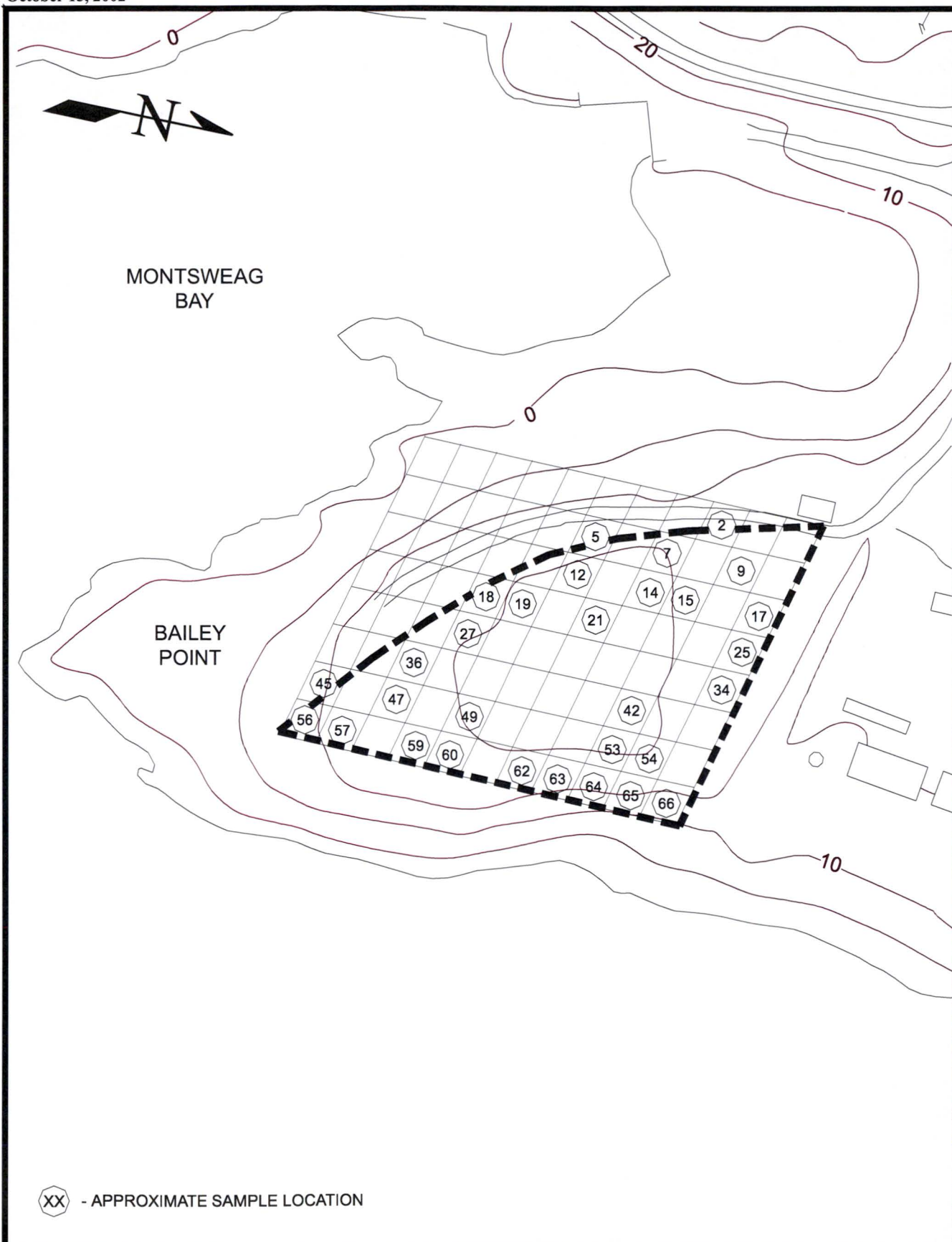








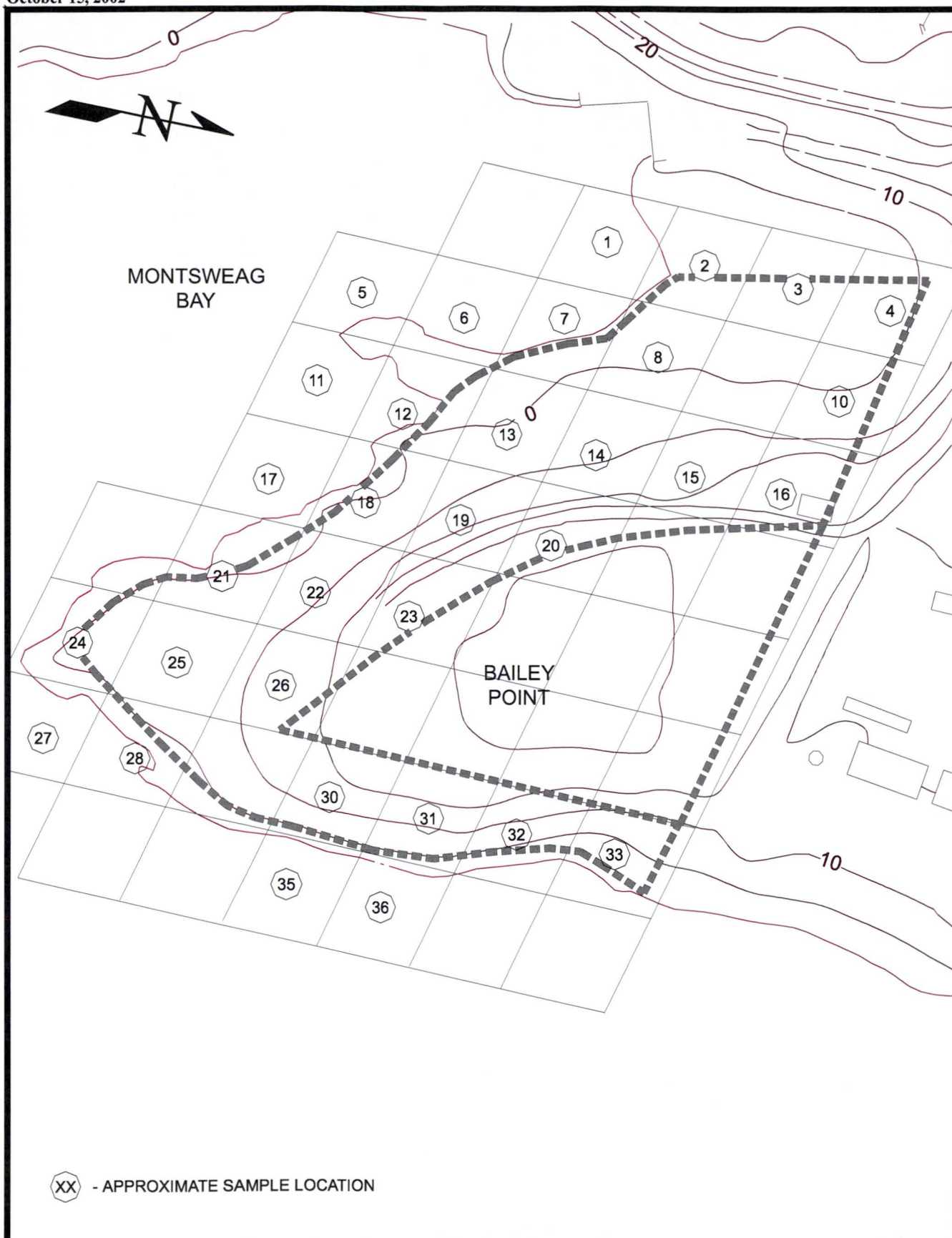


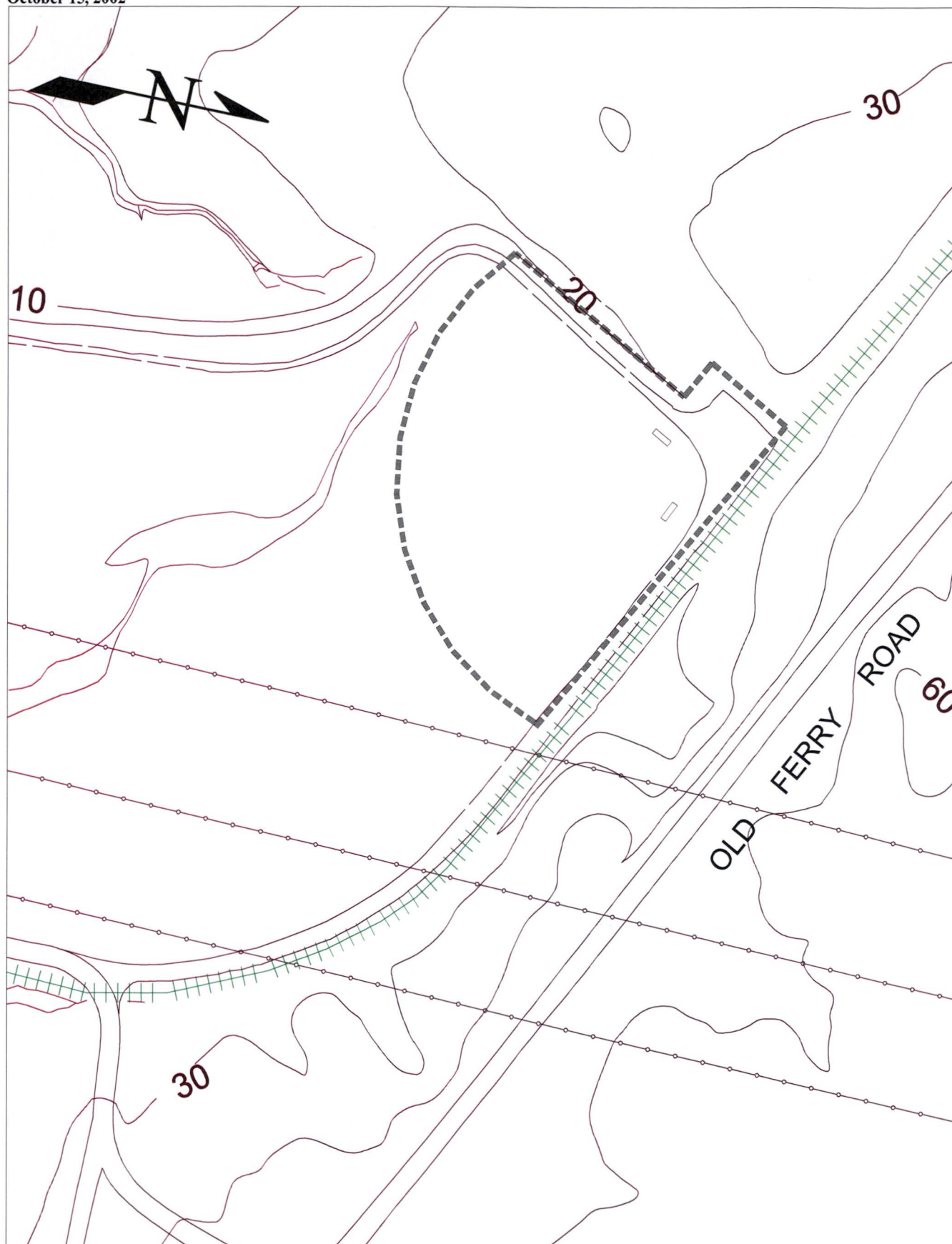


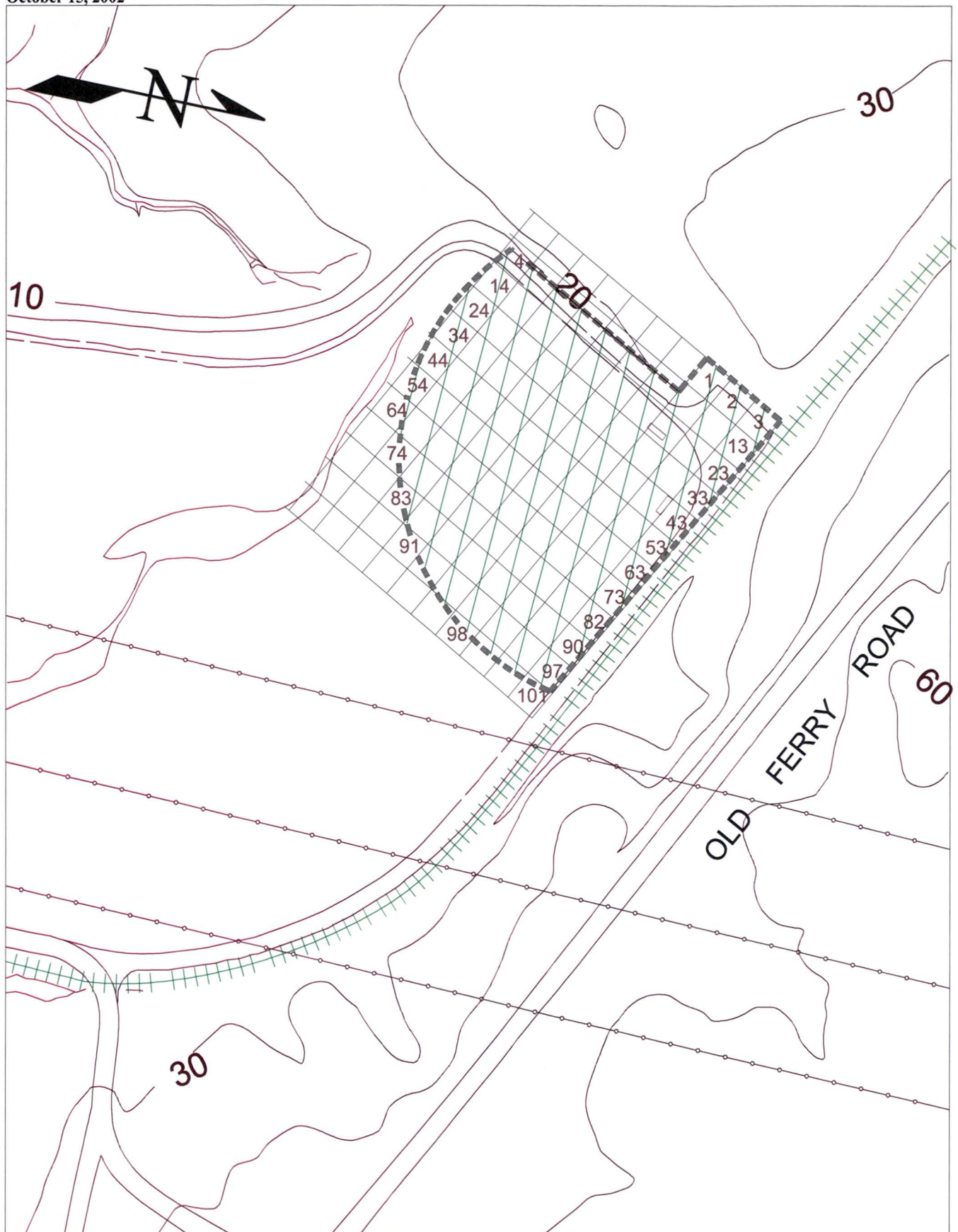


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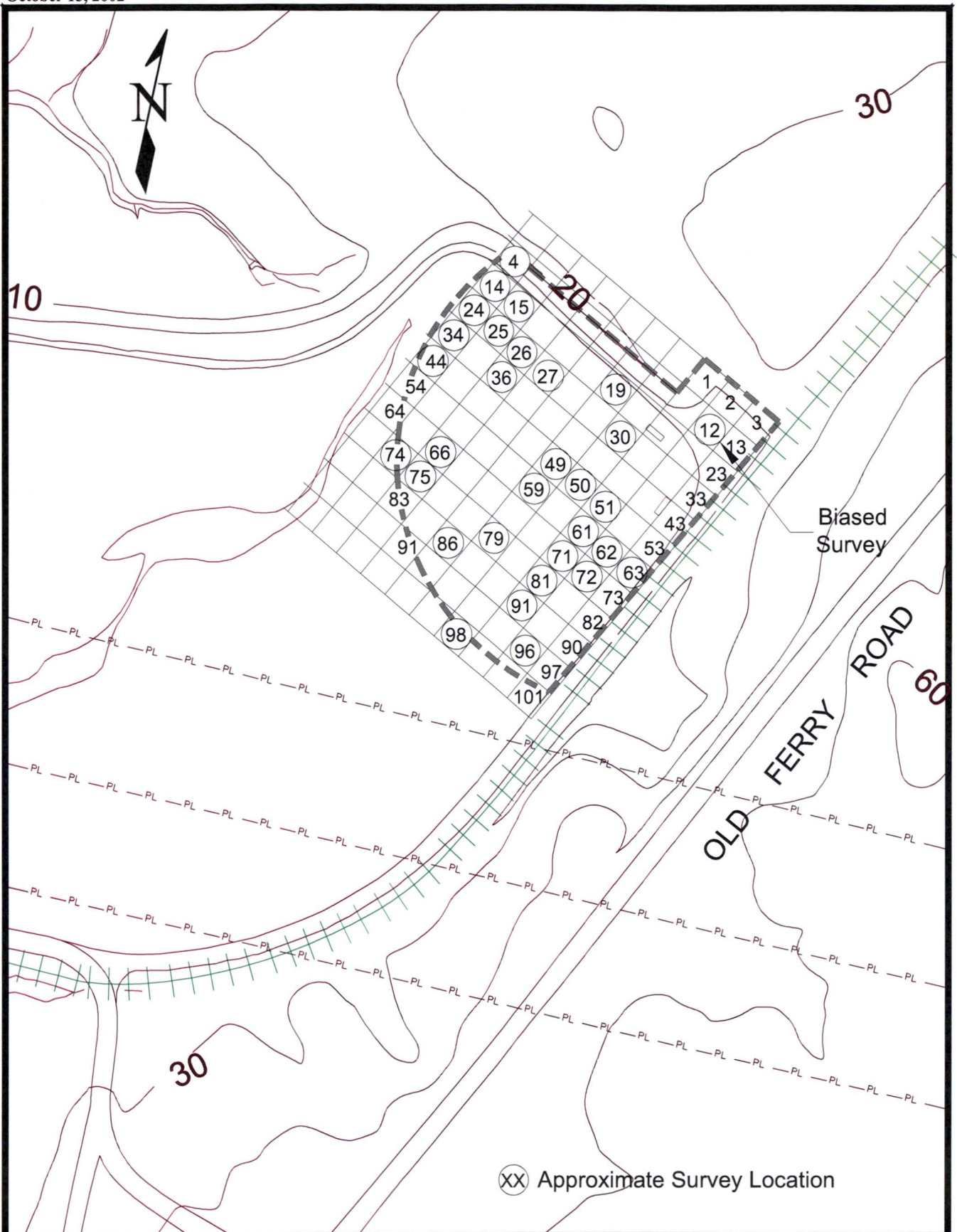


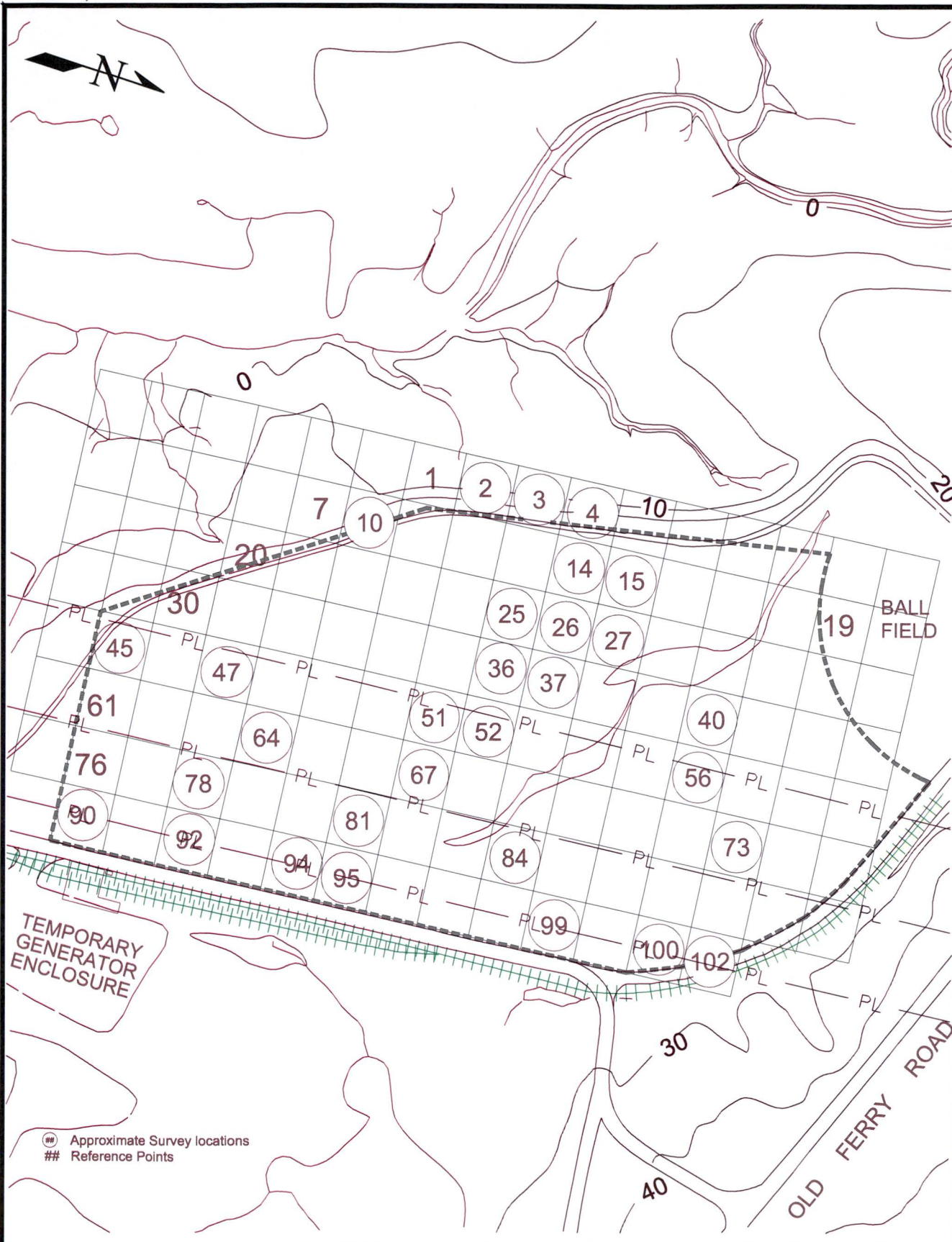




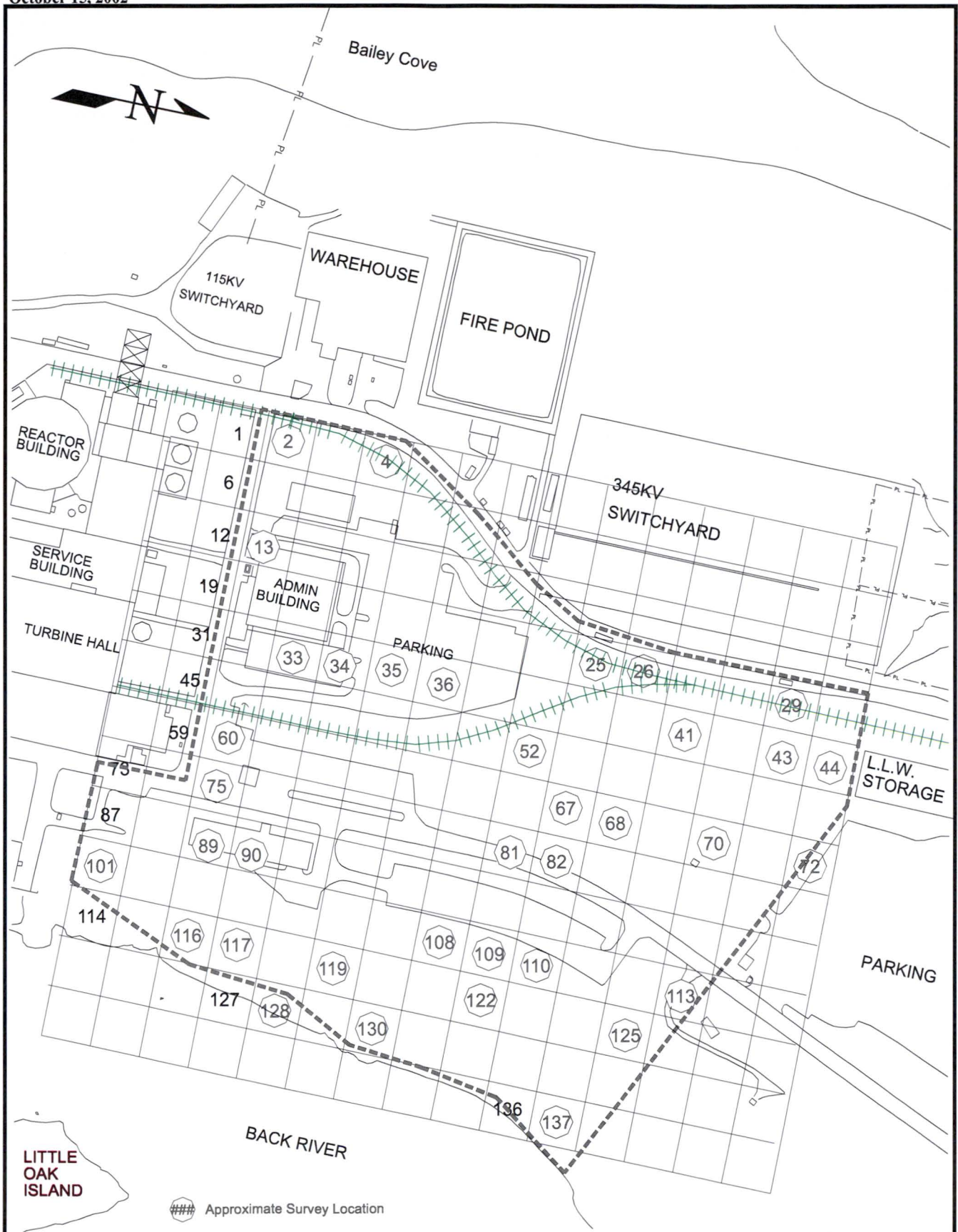


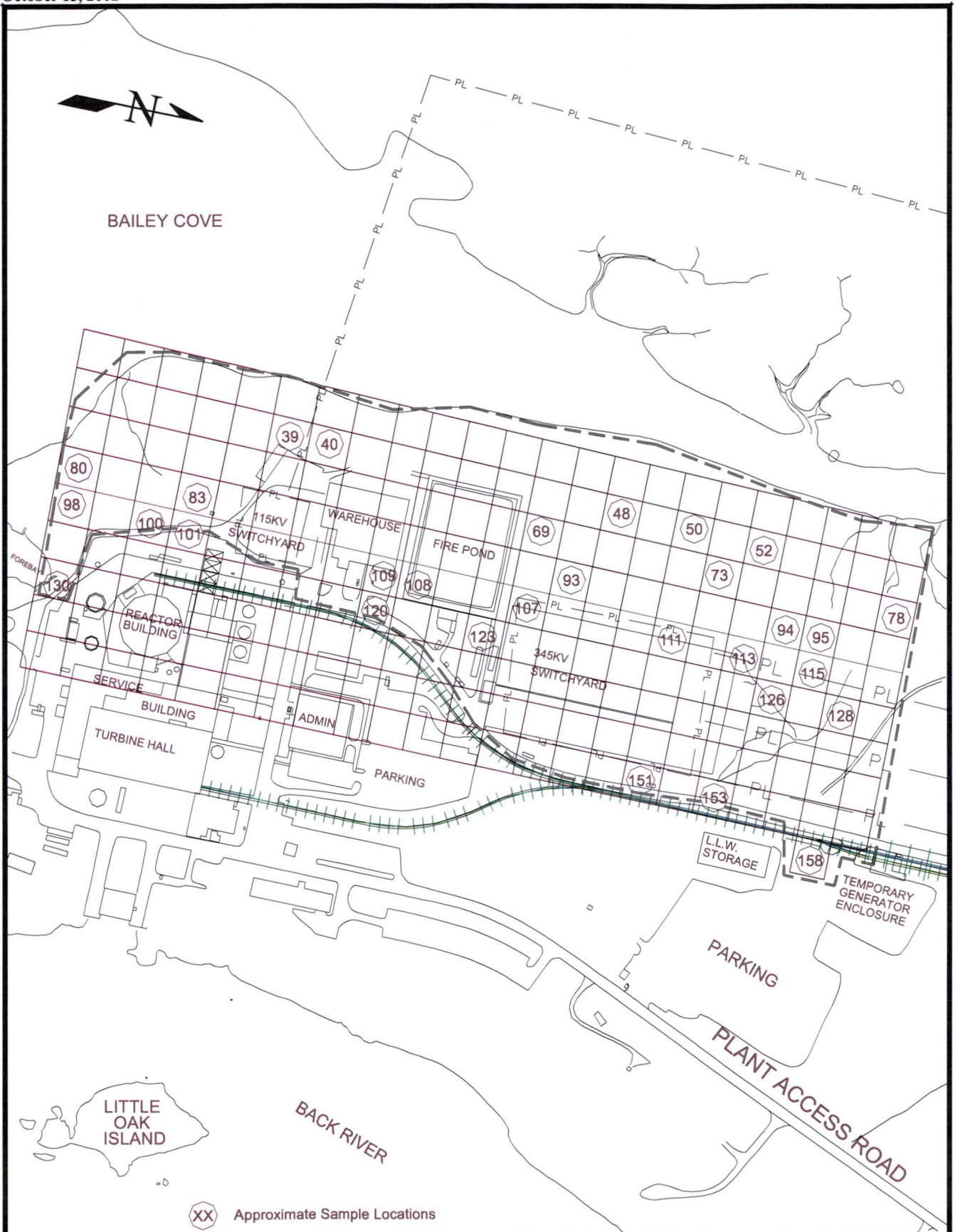




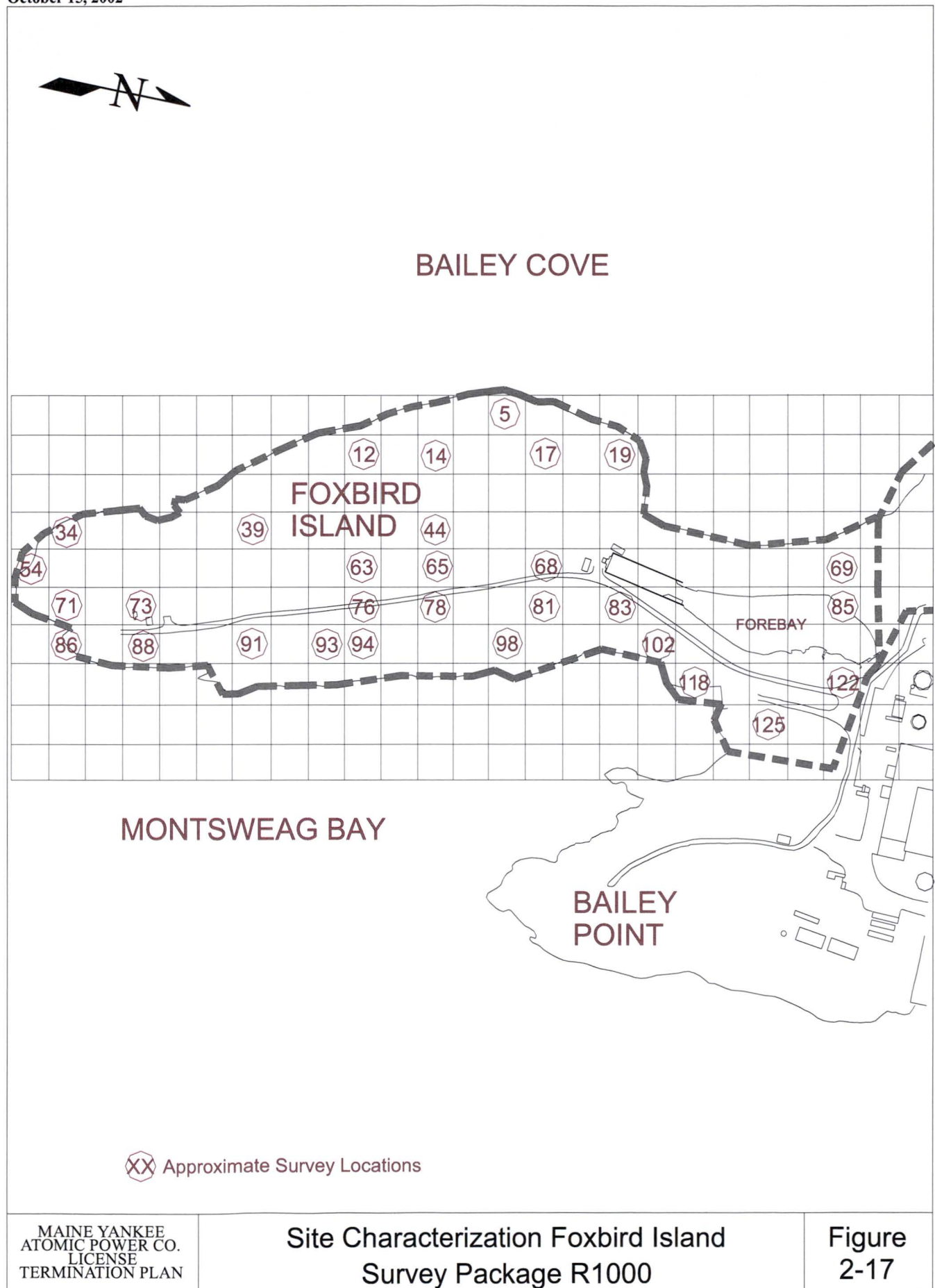




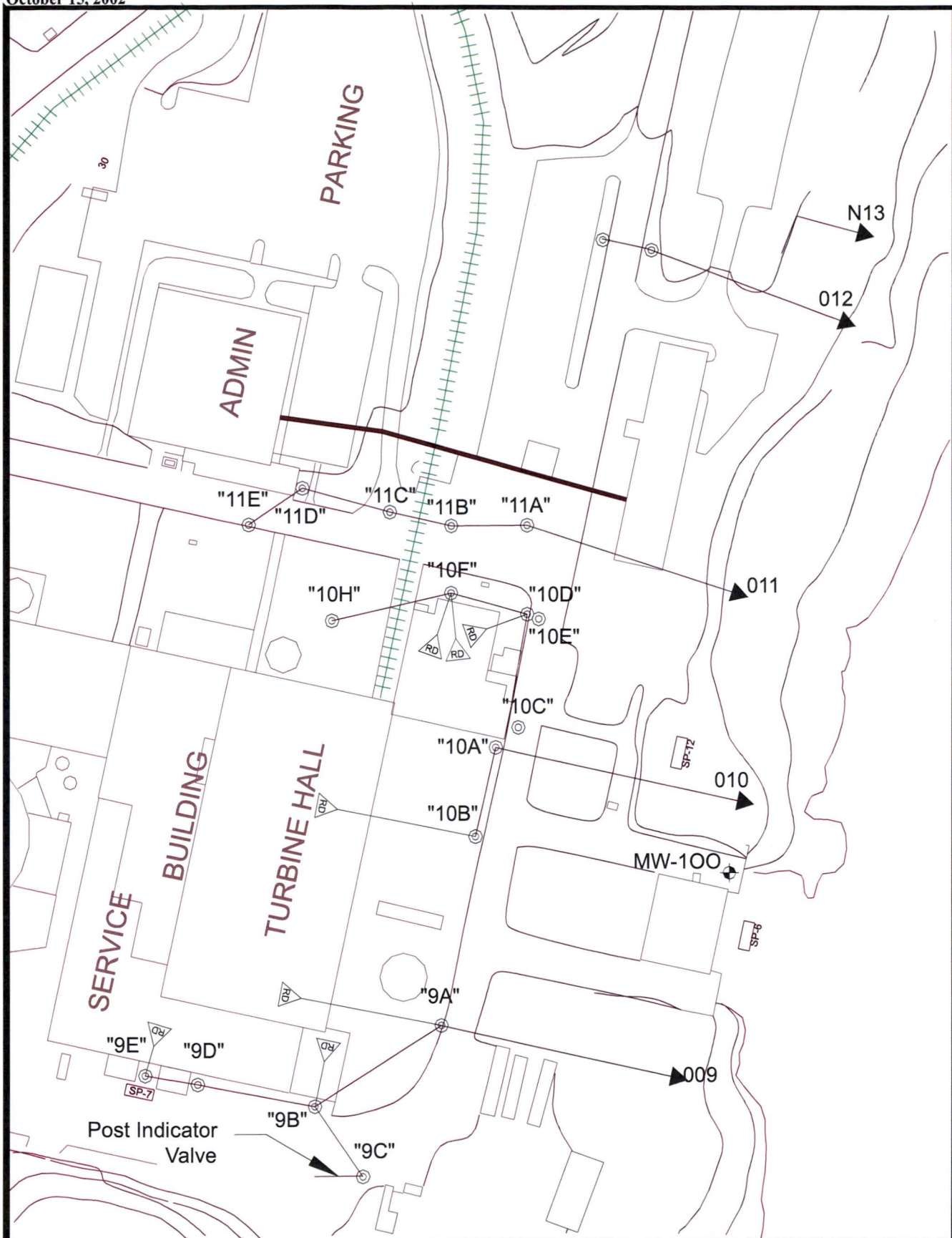


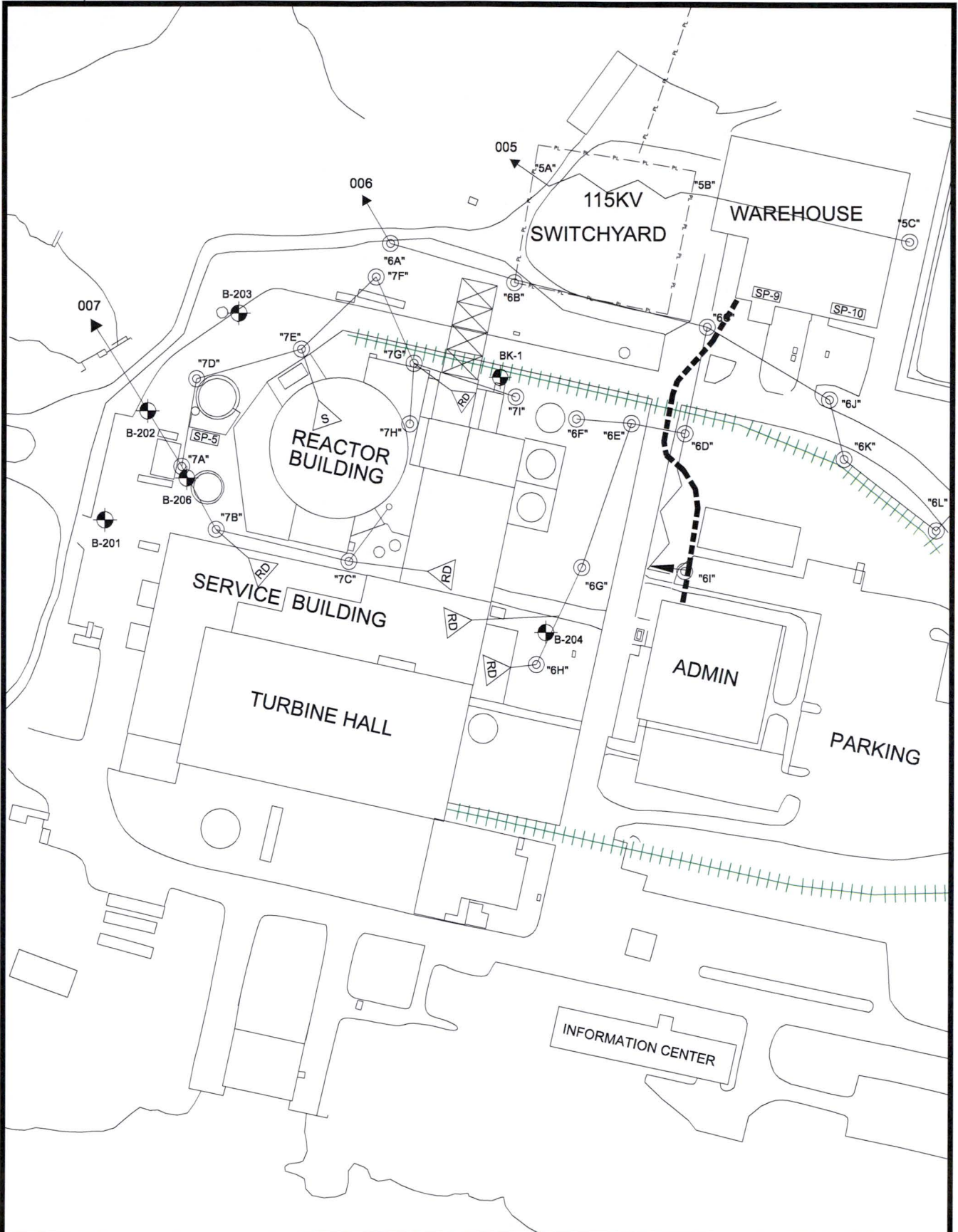




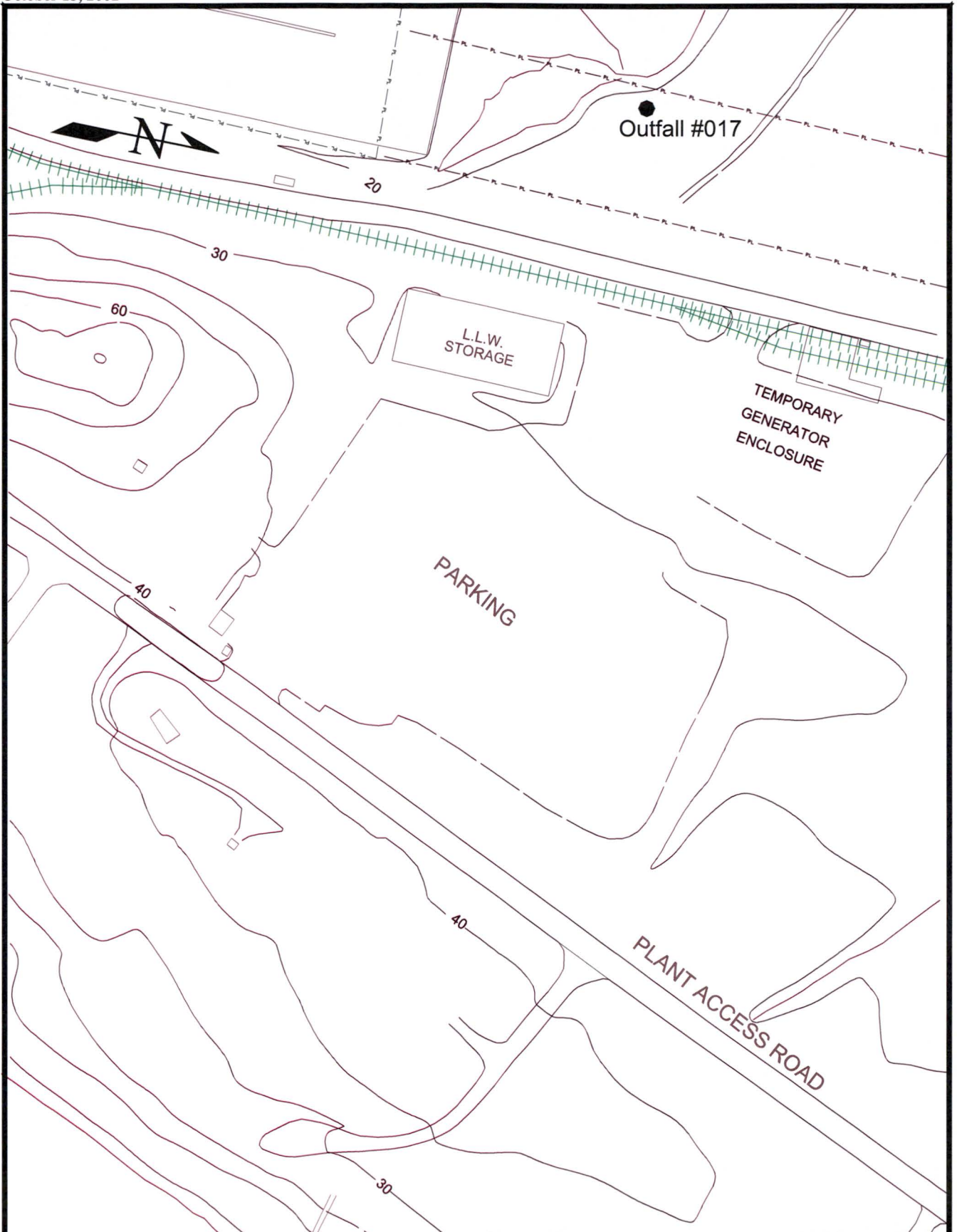


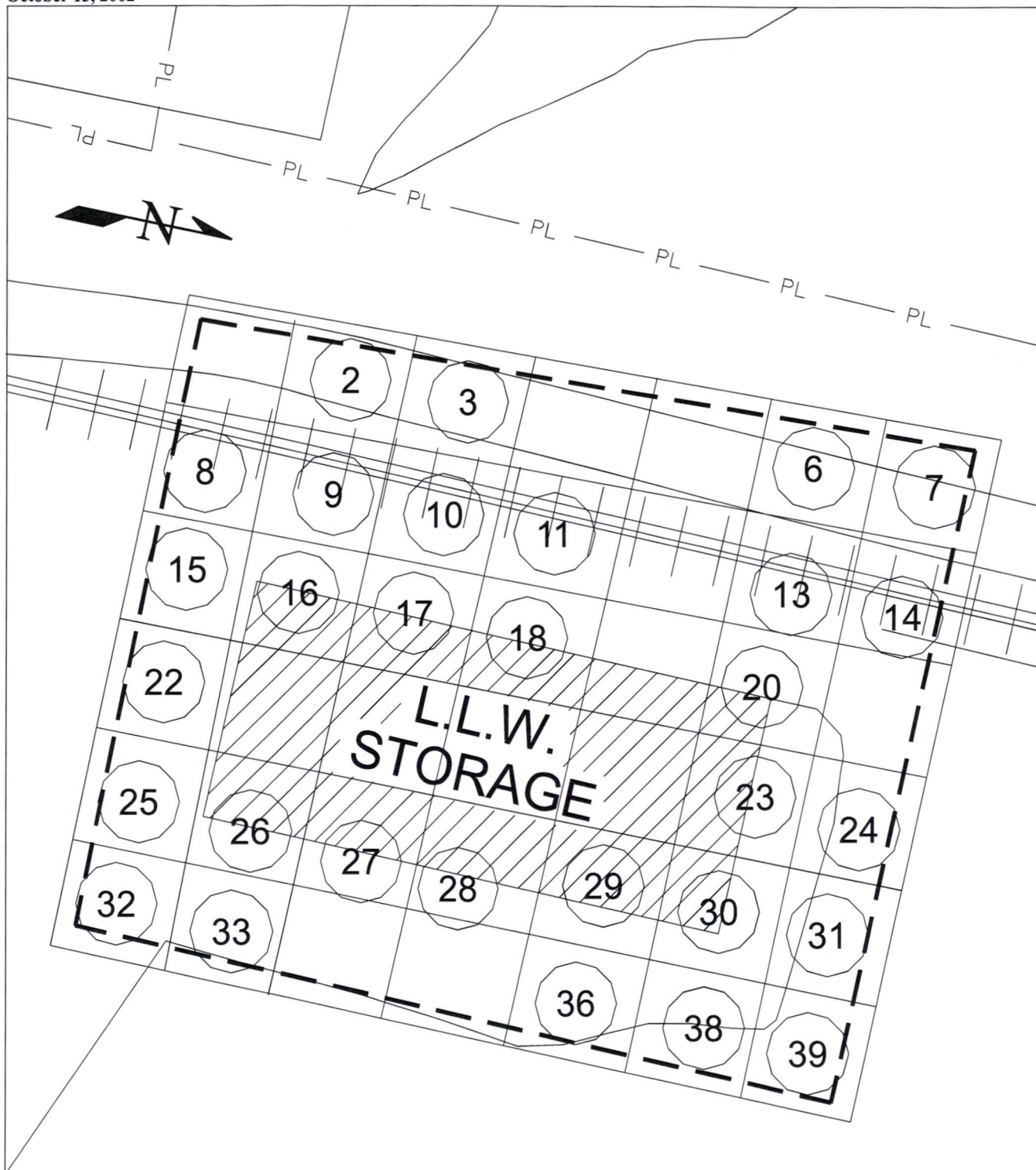






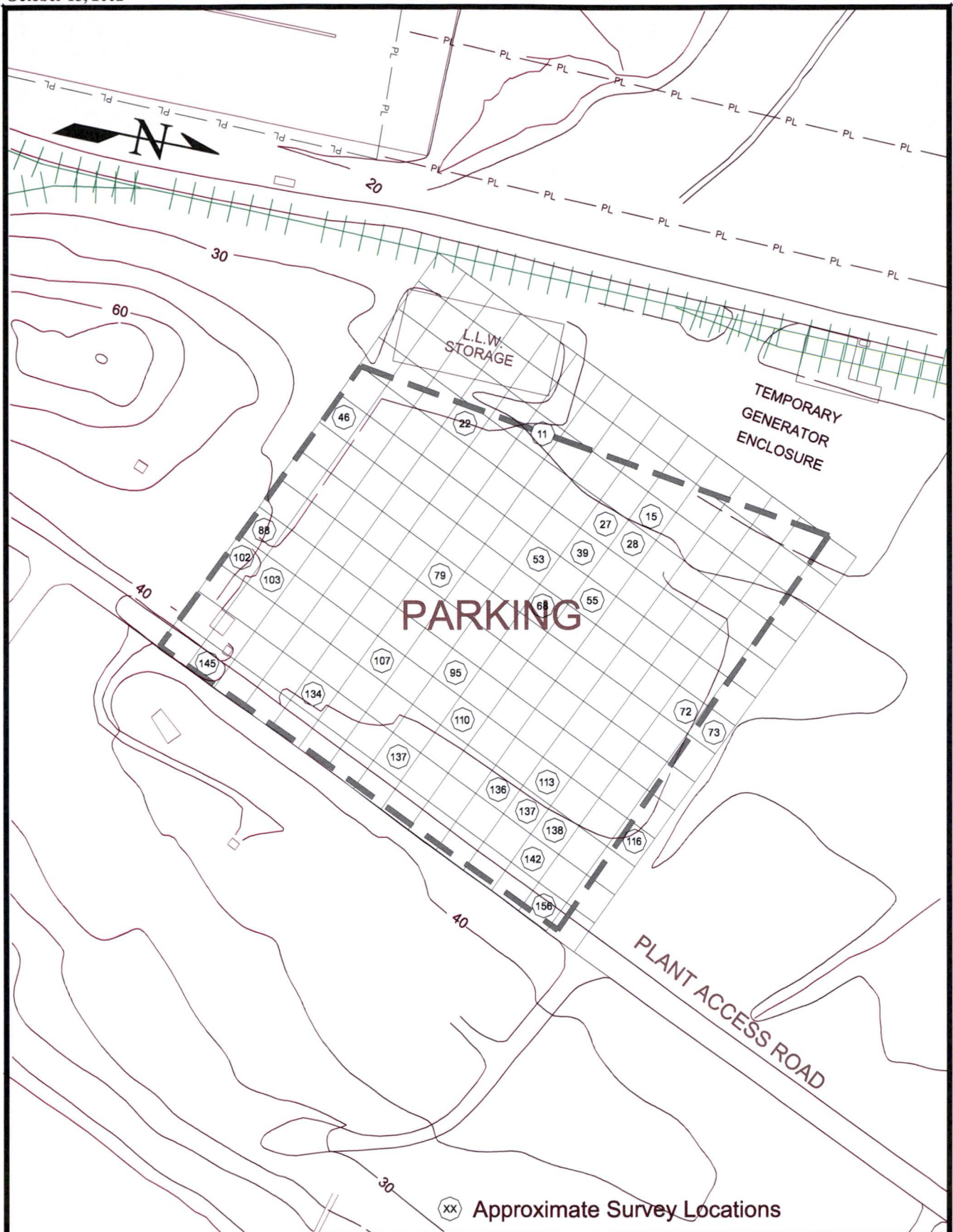


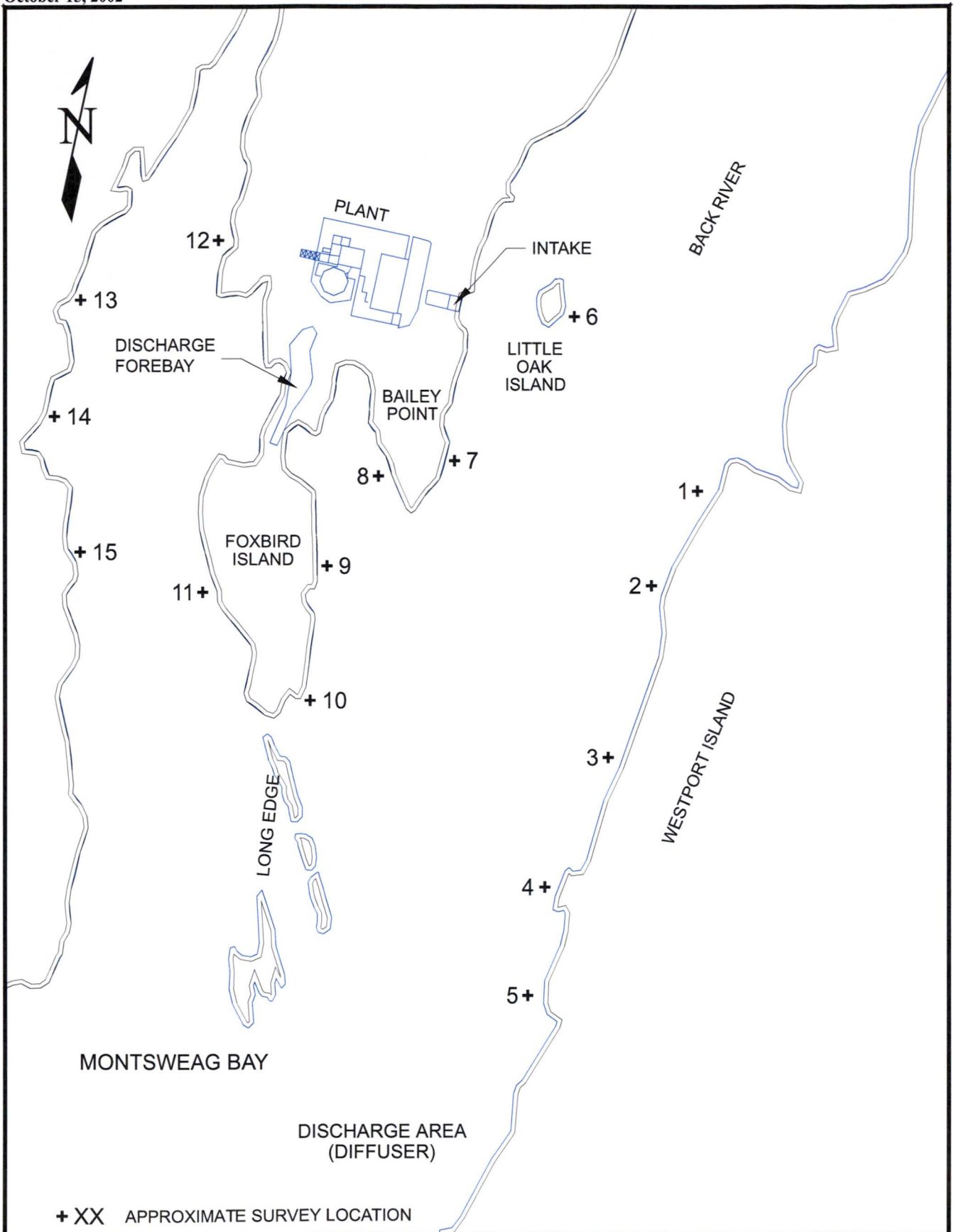


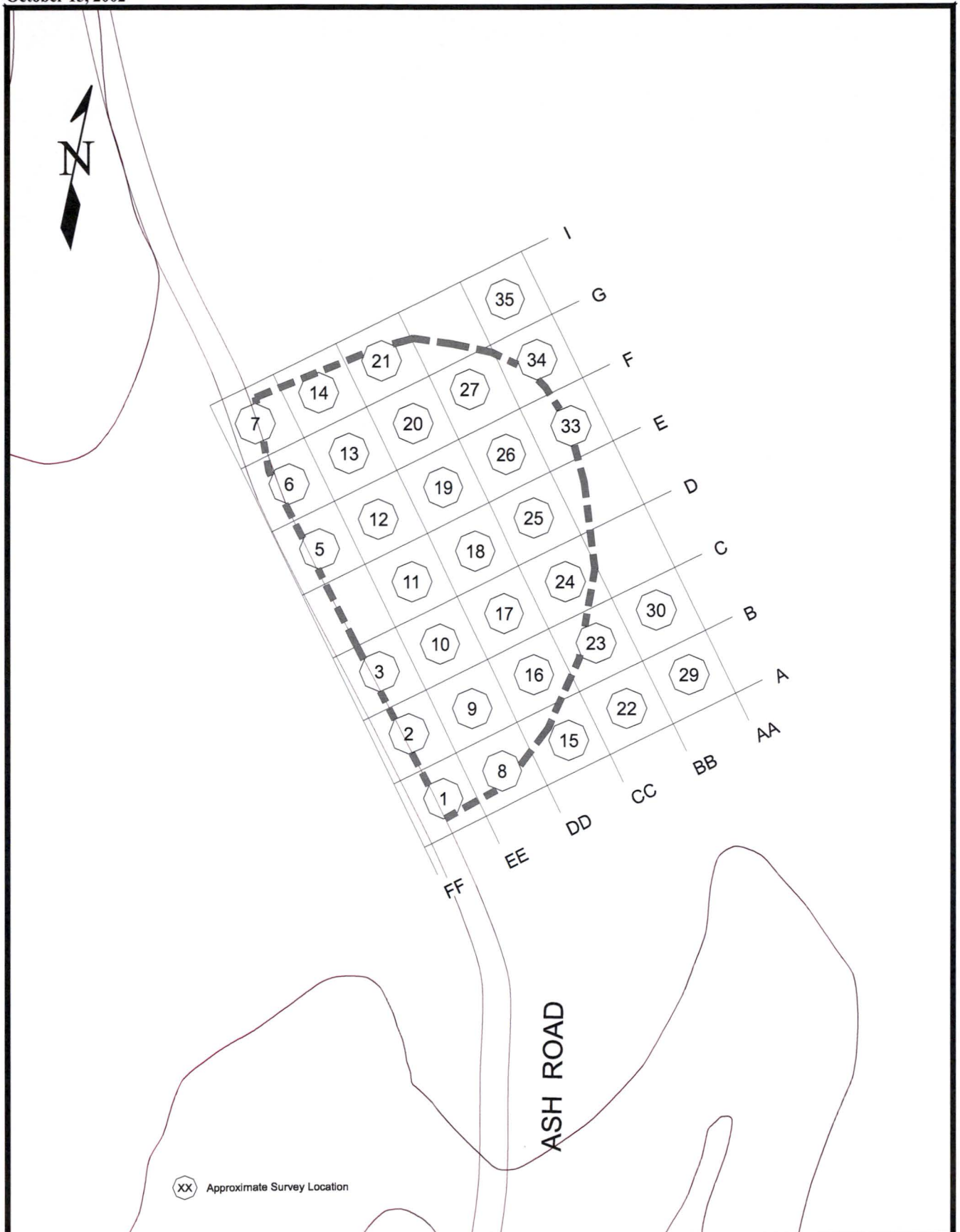


xx Approximate Survey Locations

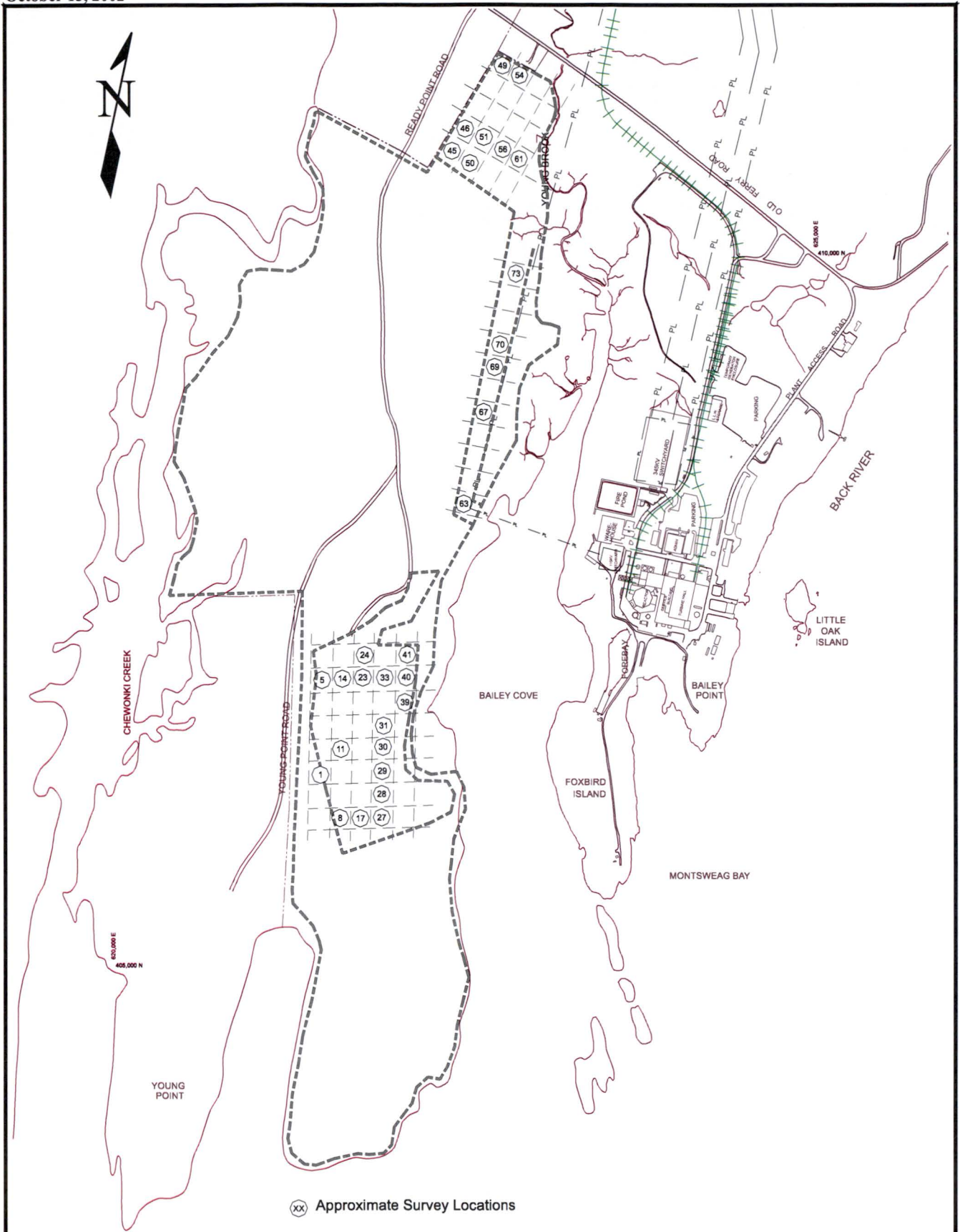




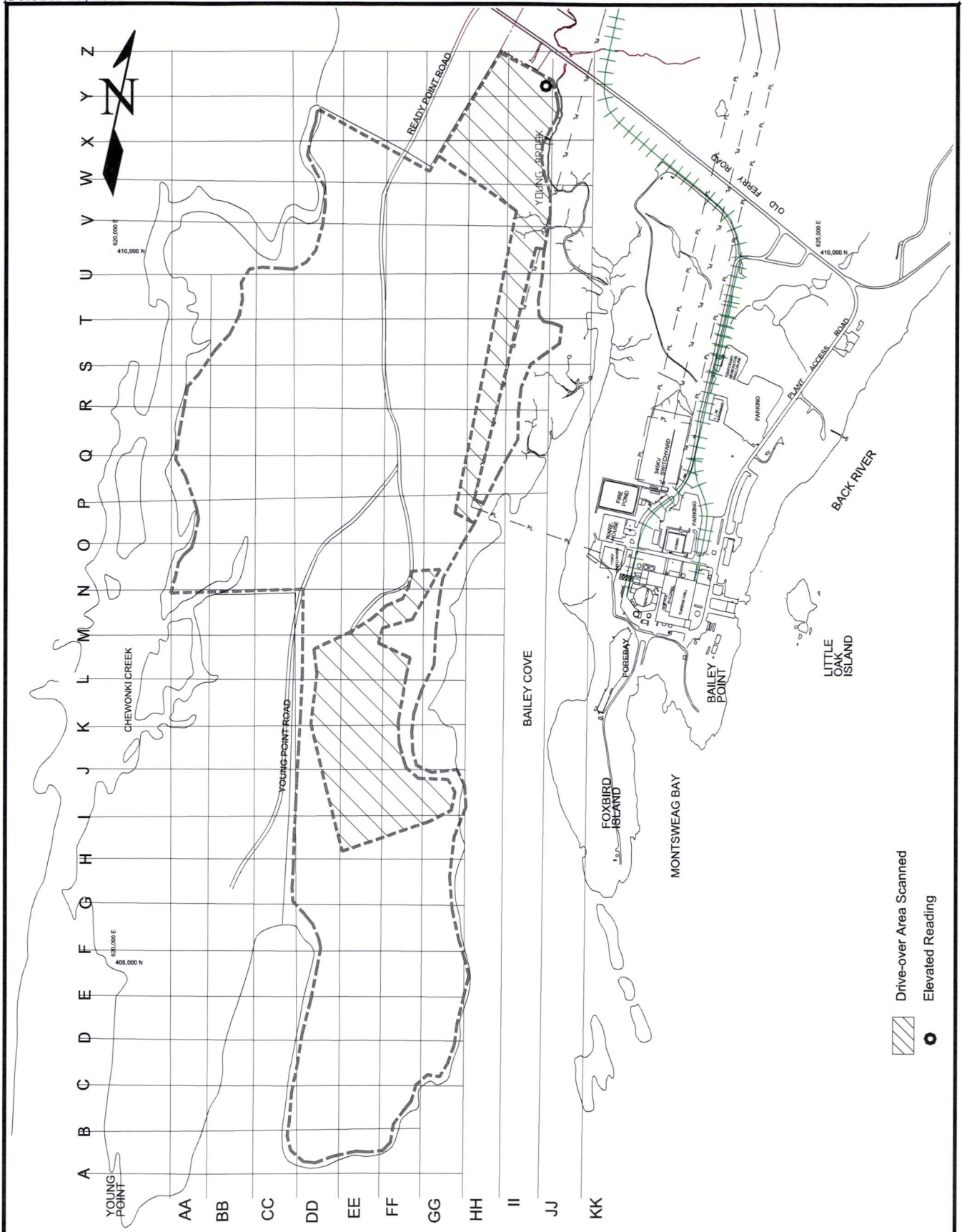








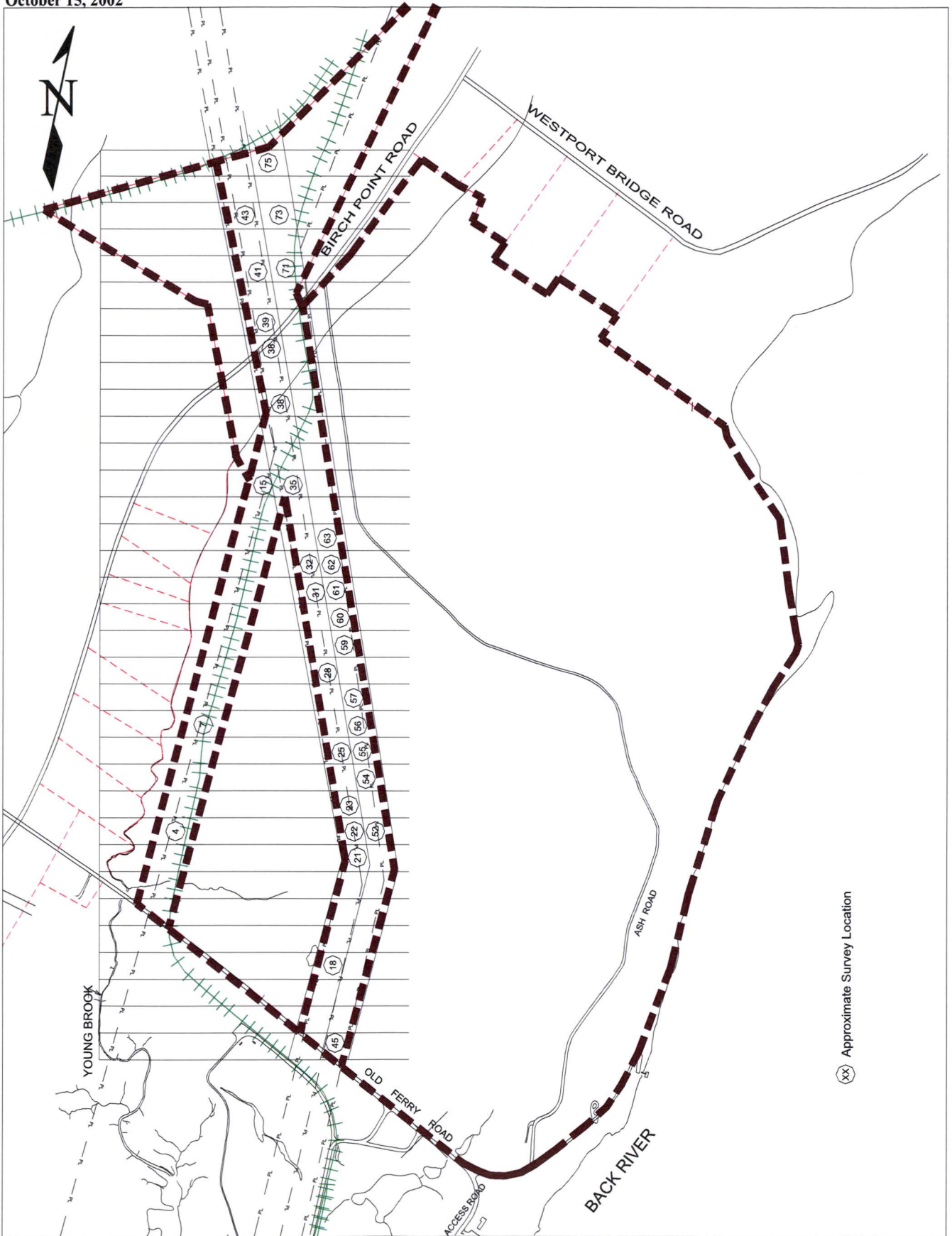


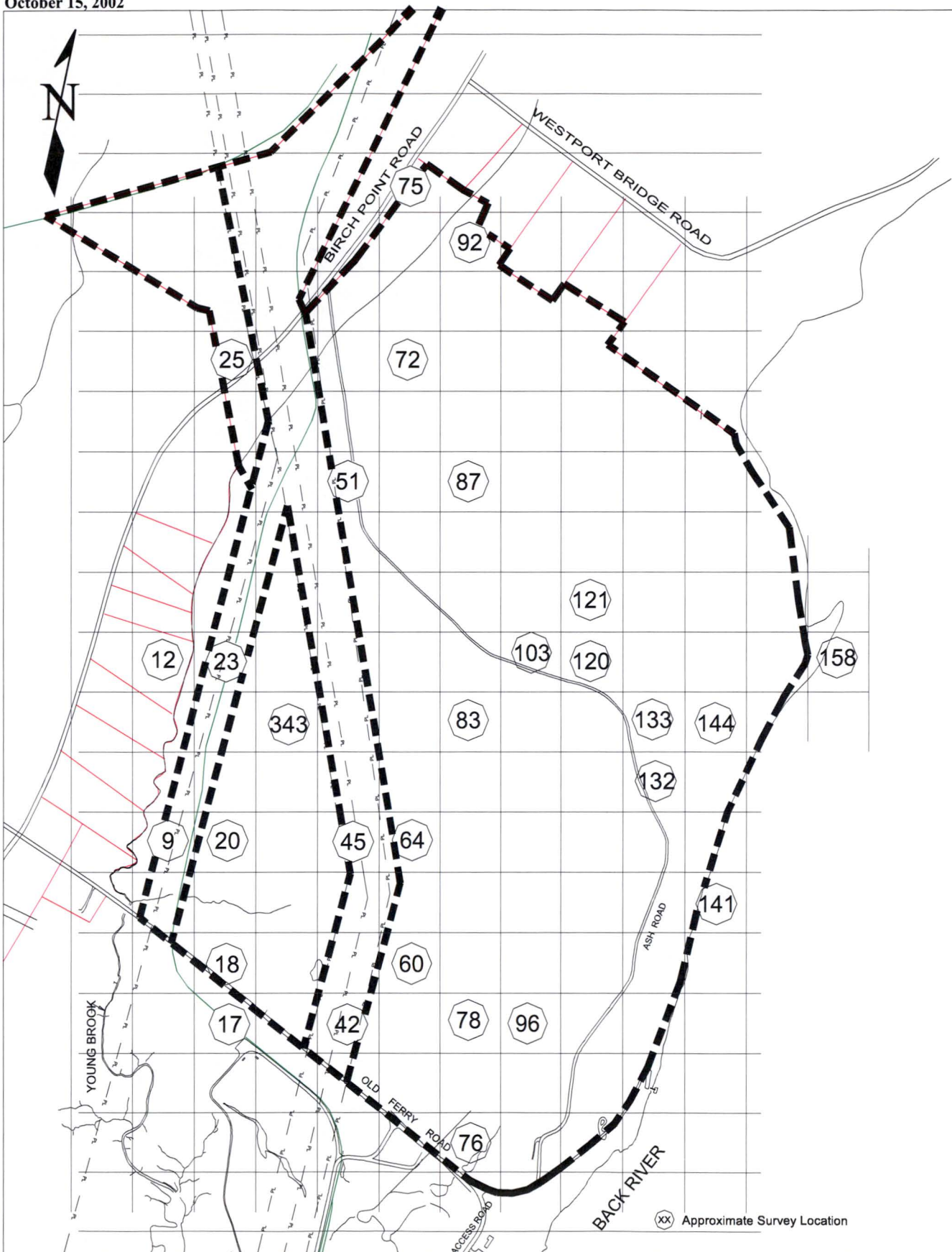


MAINE YANKEE  
ATOMIC POWER CO.  
LICENSE  
TERMINATION PLAN

Site Characterization Owner Controlled Area  
Survey Package R1600-4

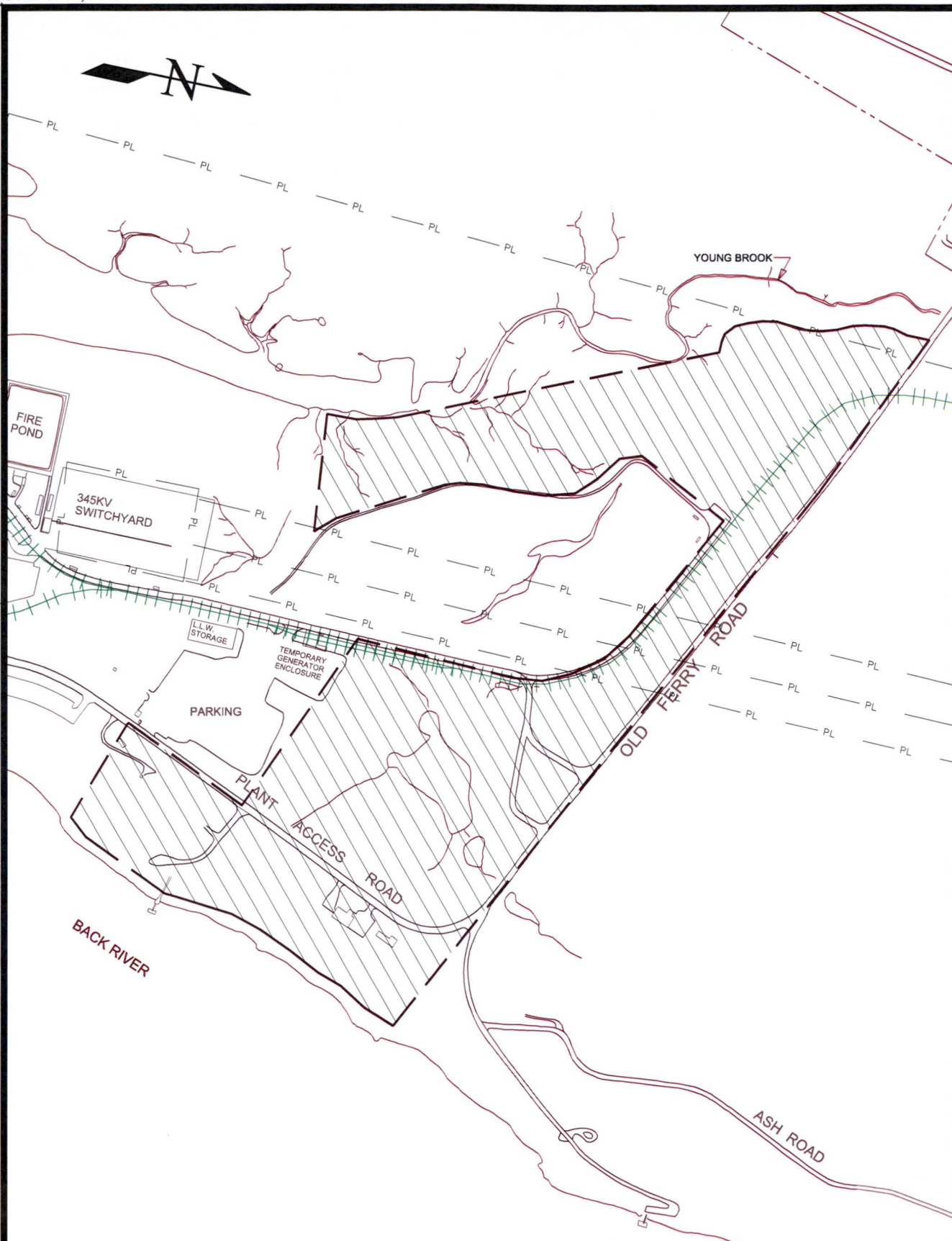
Figure  
2-26

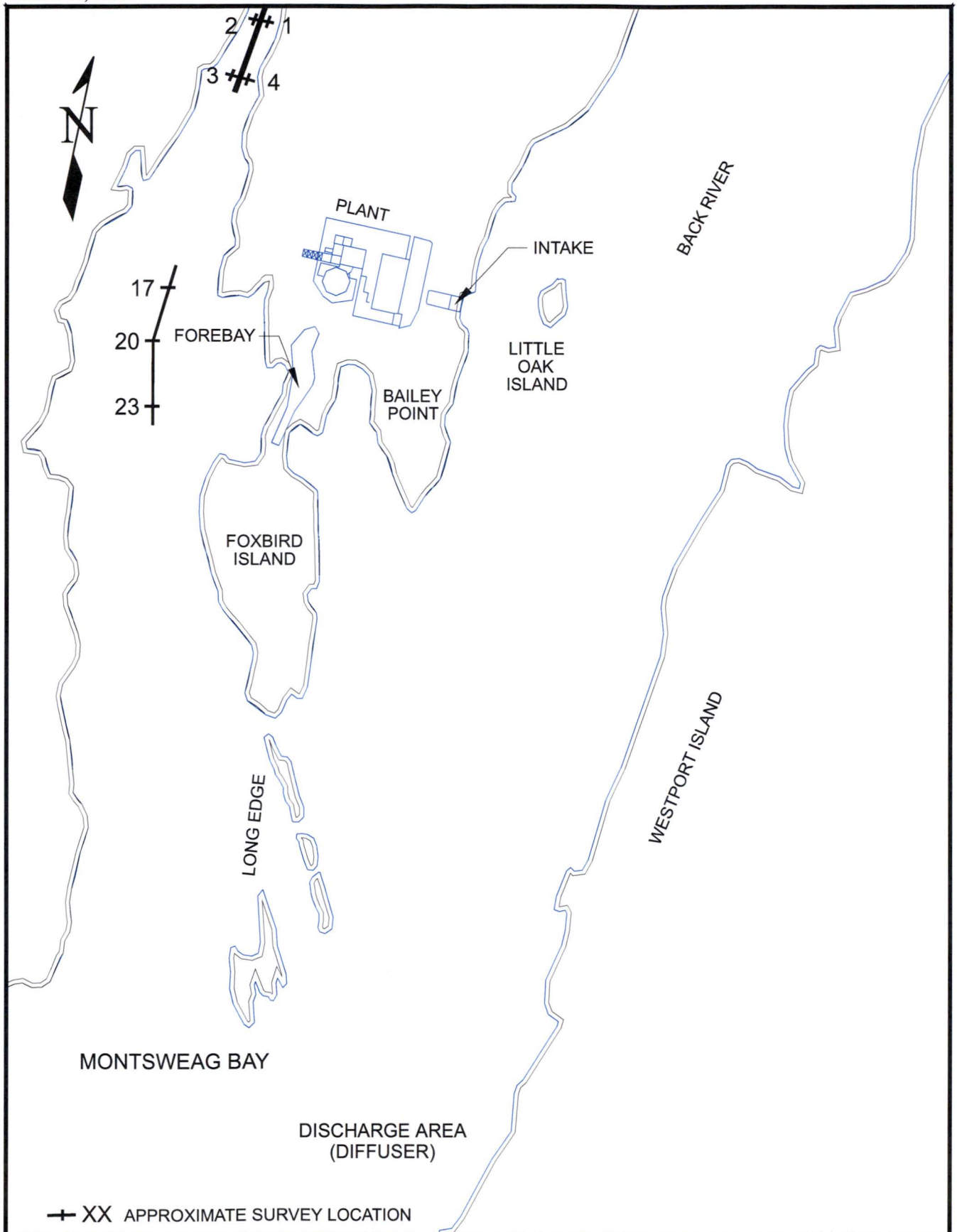


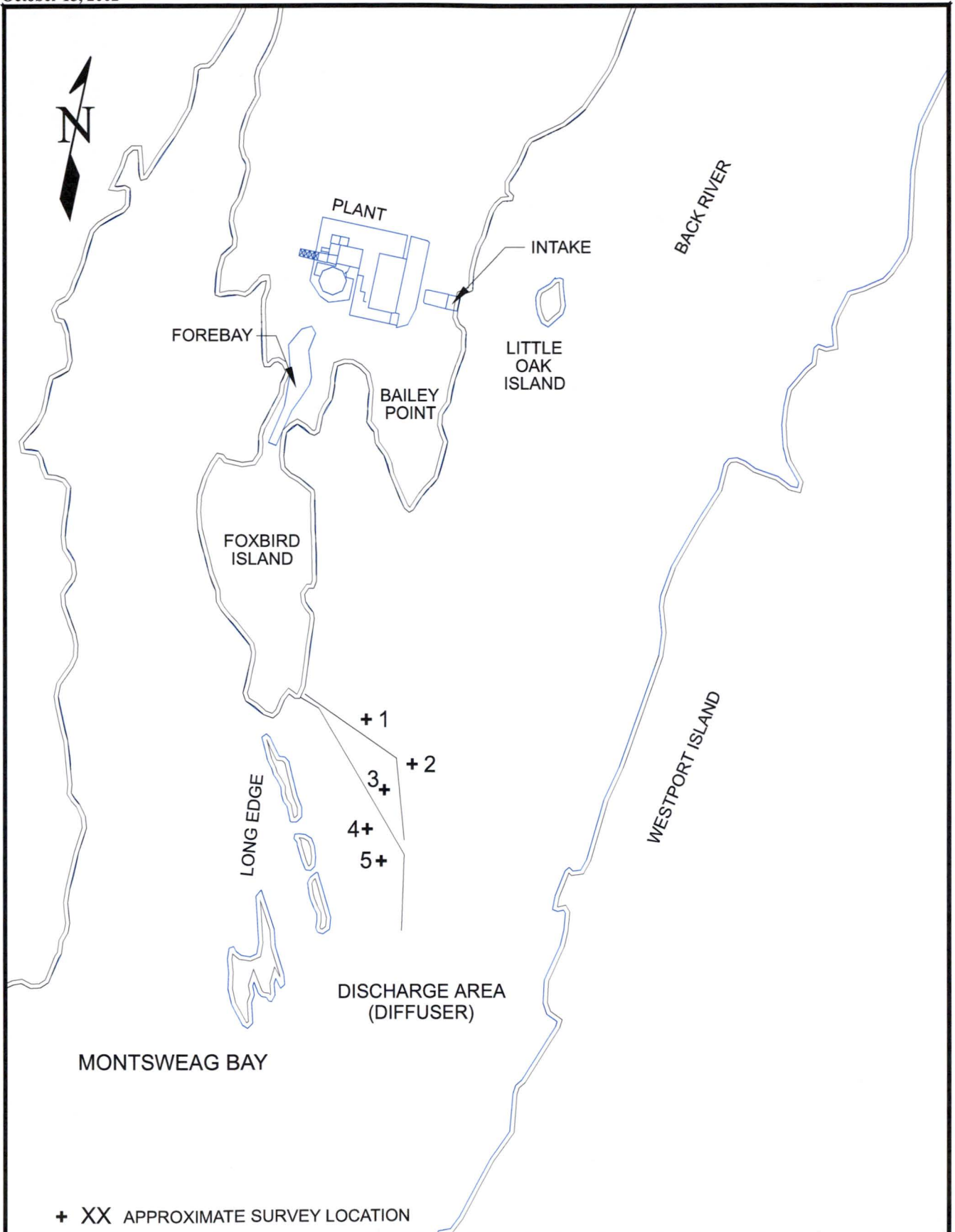


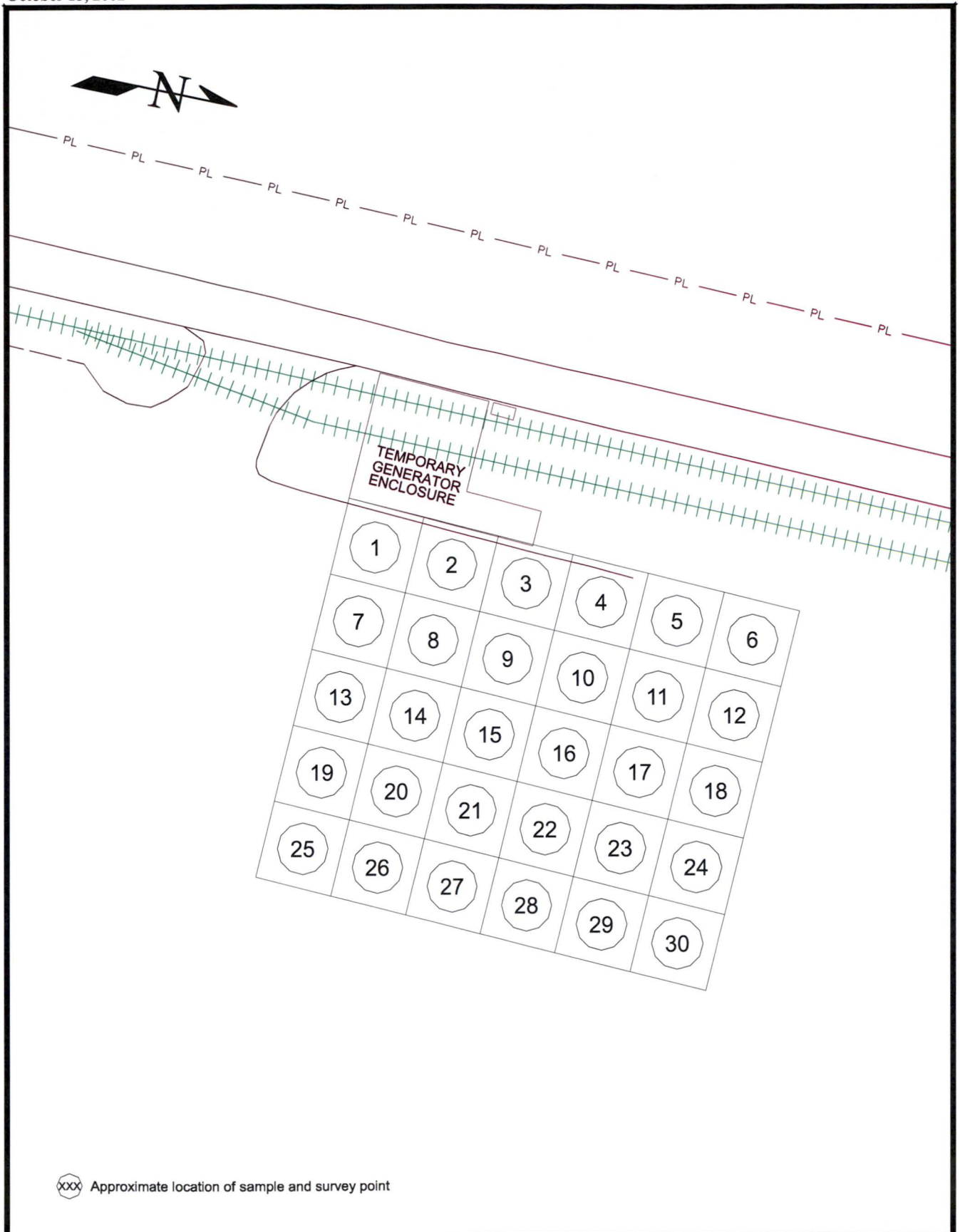
<p>MAINE YANKEE  ATOMIC POWER CO.  LICENSE  TERMINATION PLAN</p>	<p>Site Characterization Owner Controlled Area  North of Old Ferry Rd Survey Package R1700-4</p>	<p>Figure  2-28</p>
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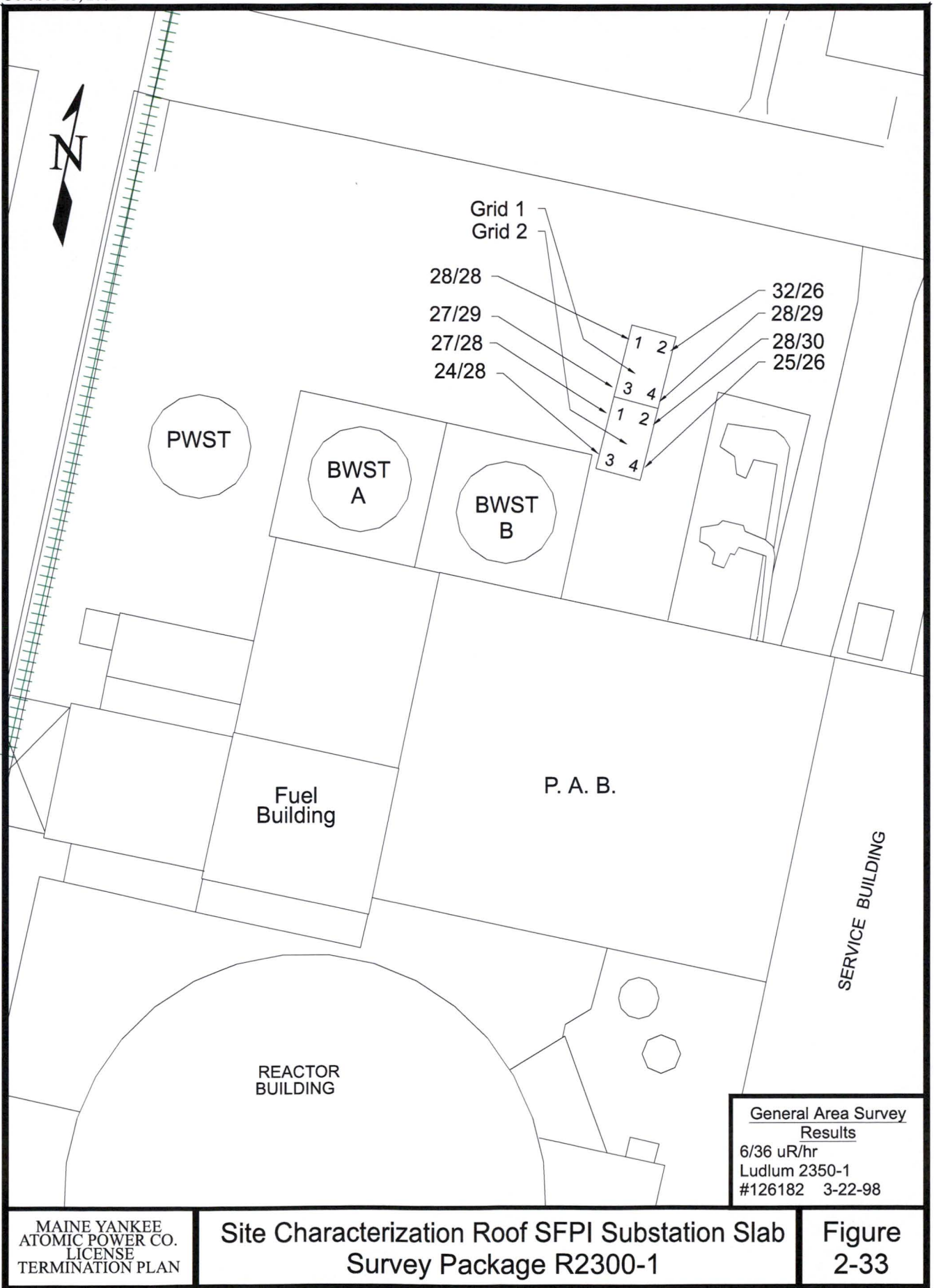




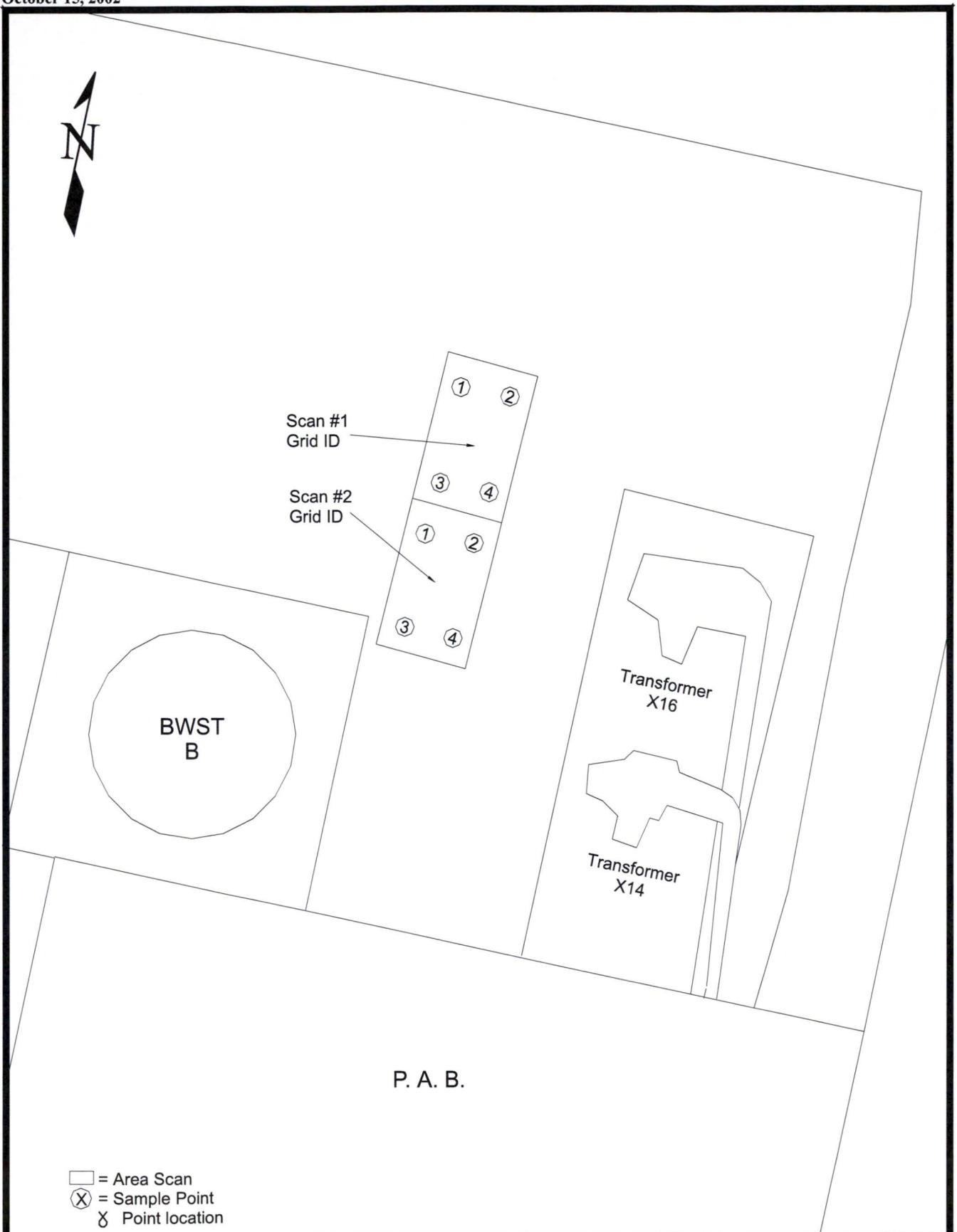


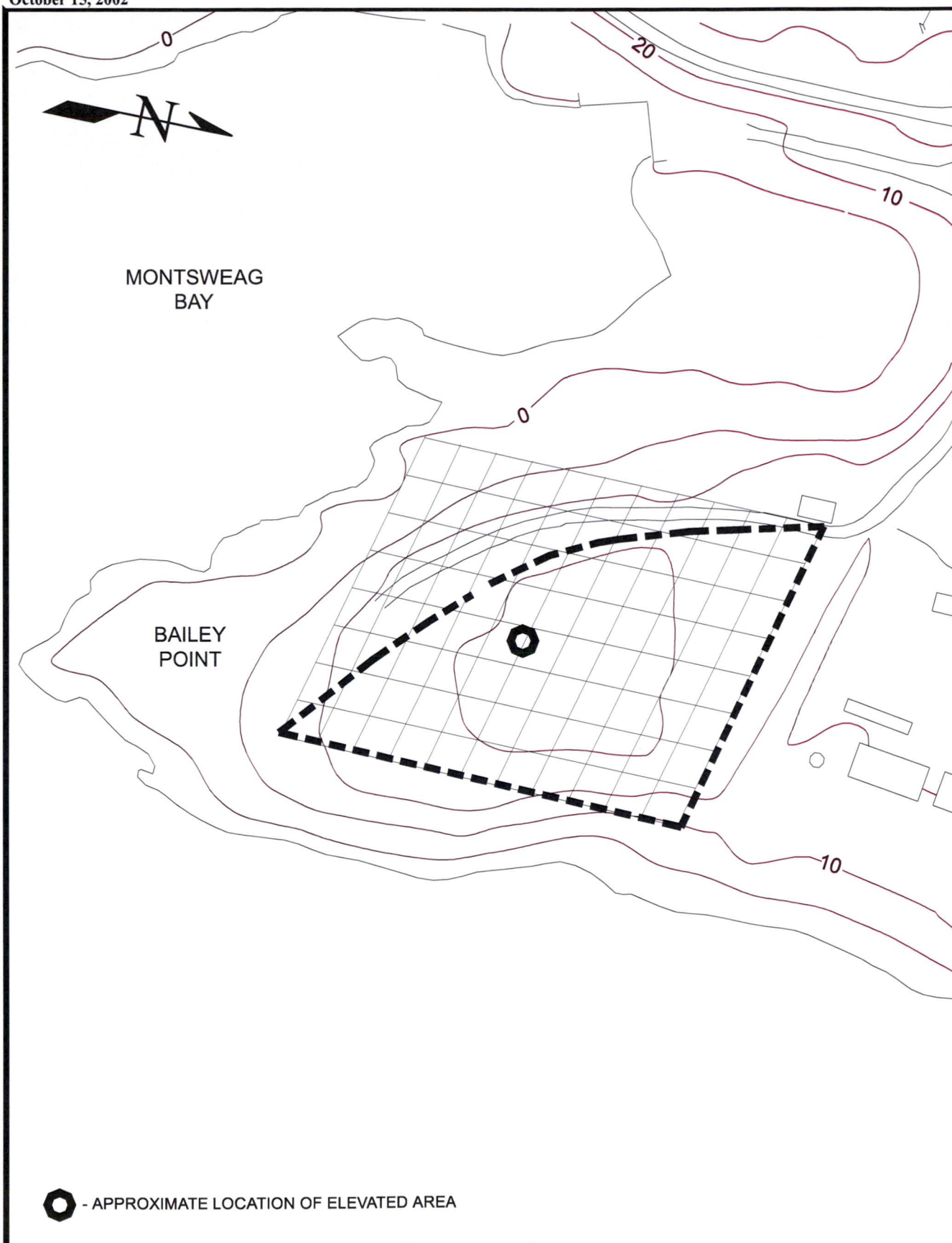


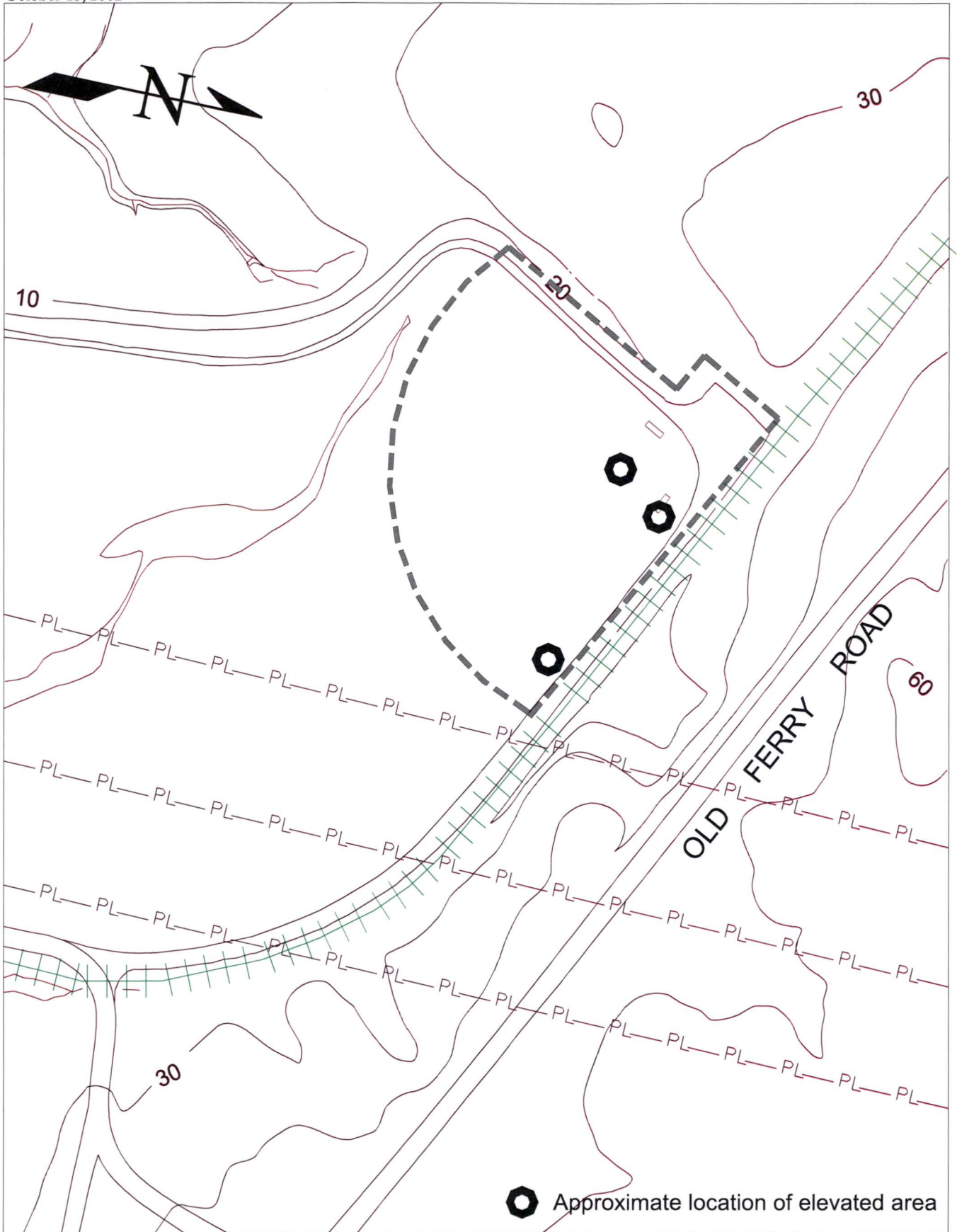




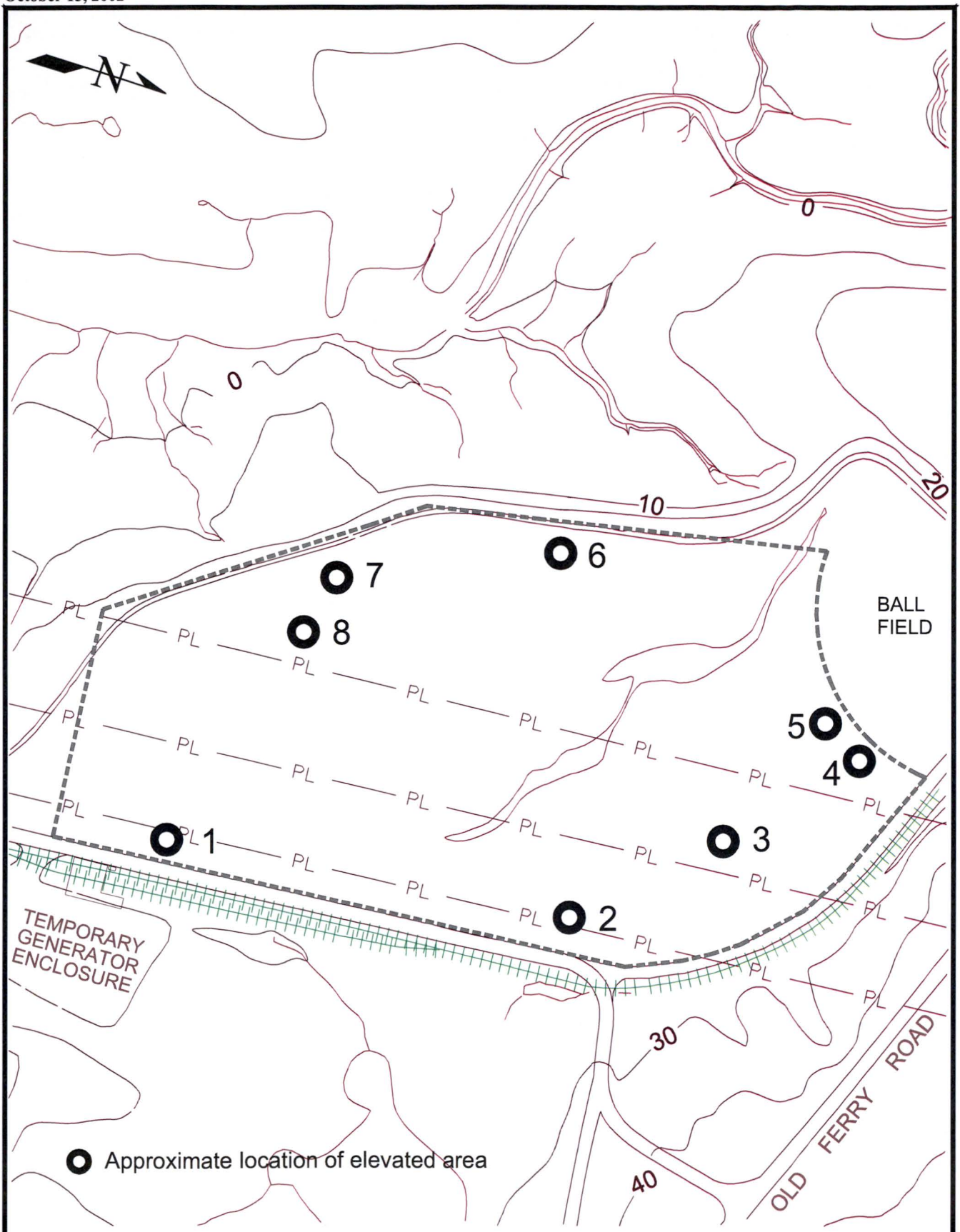


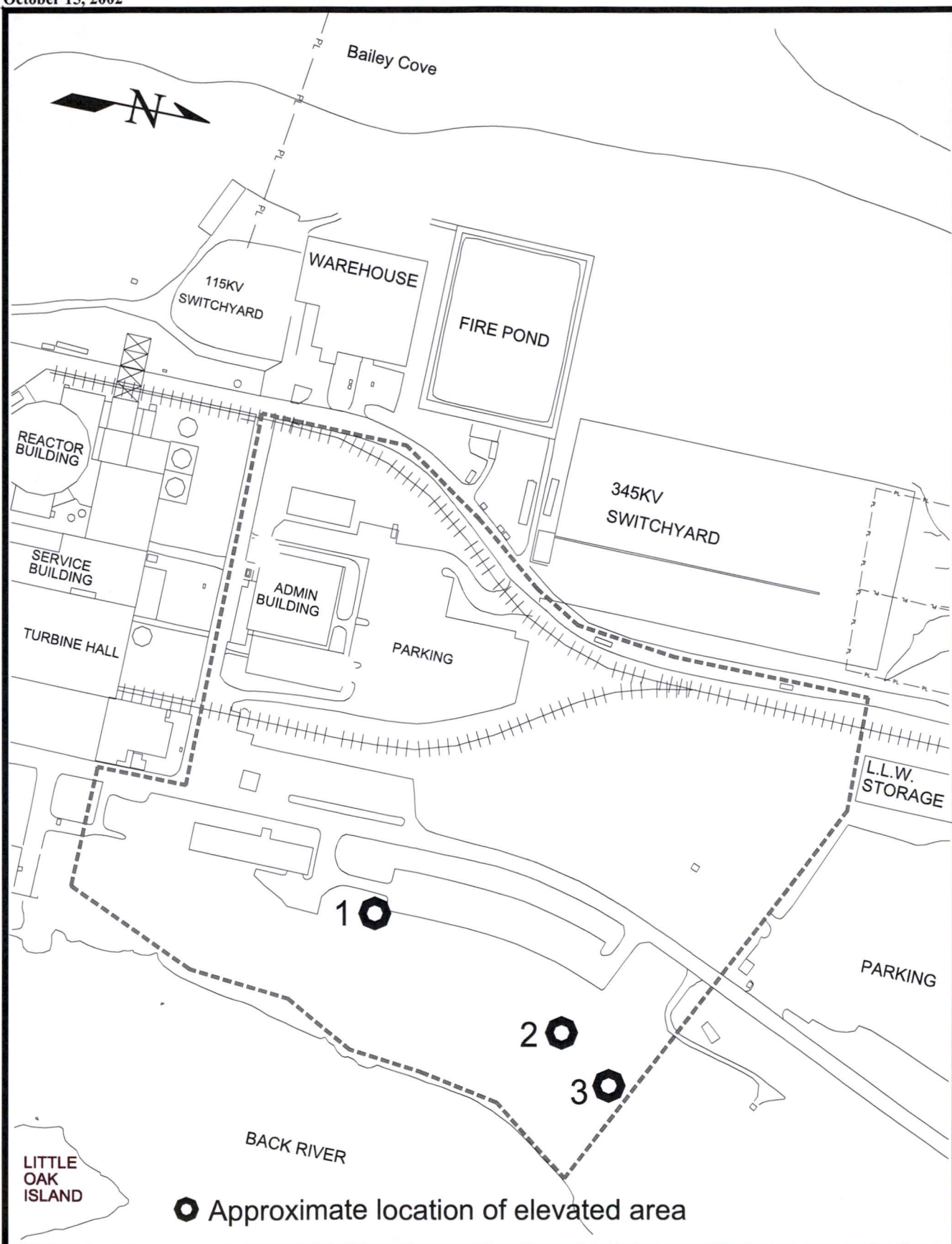


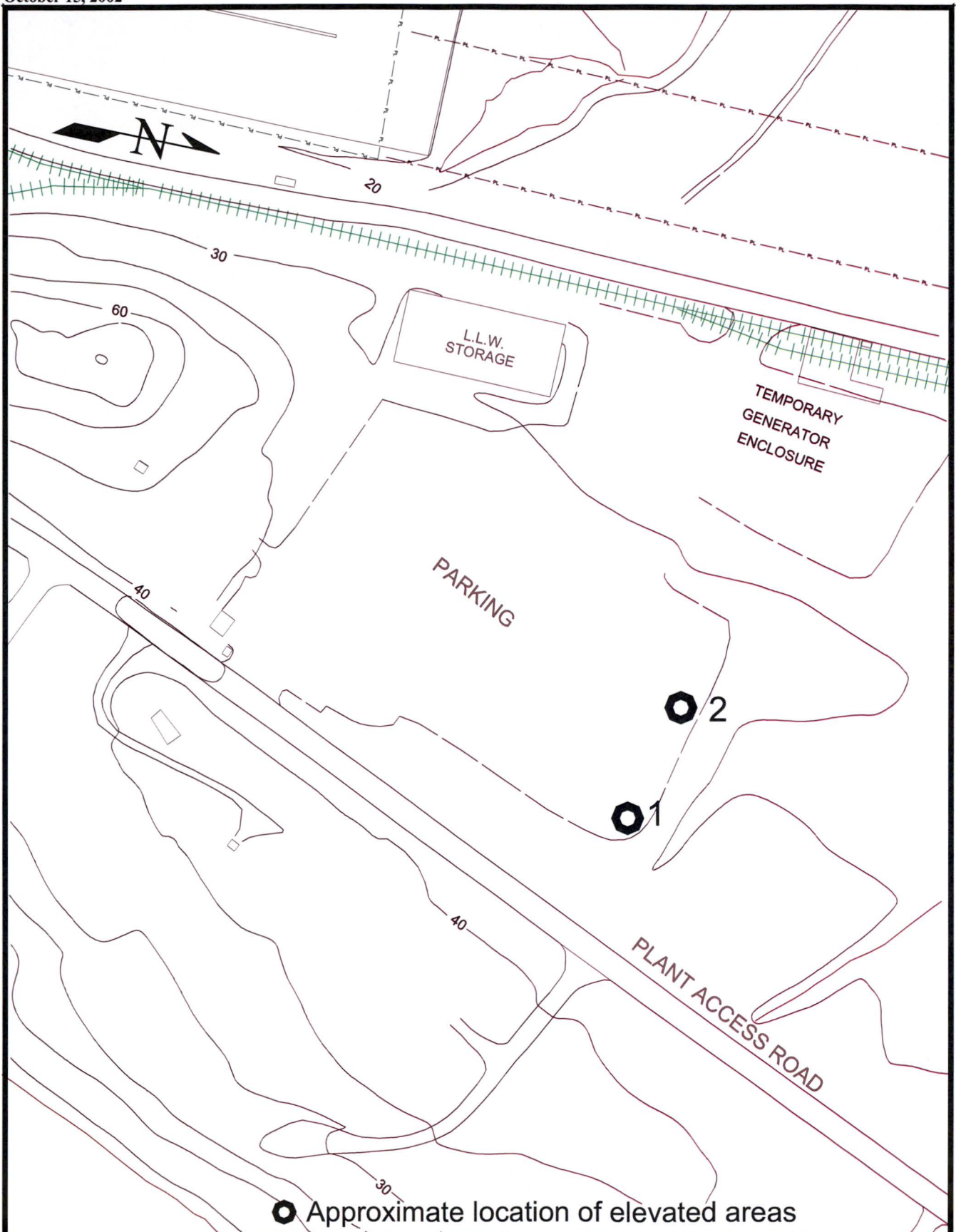




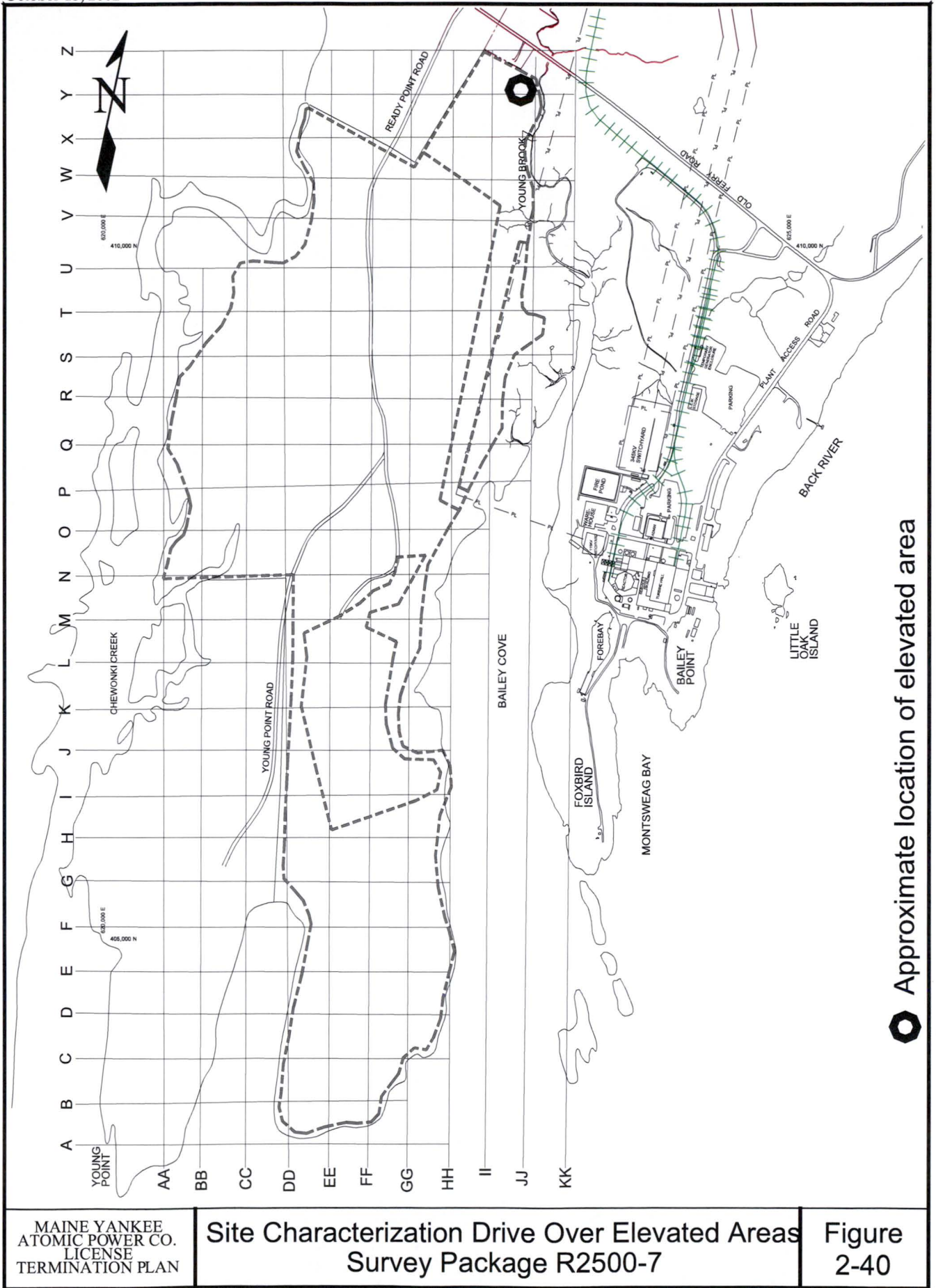


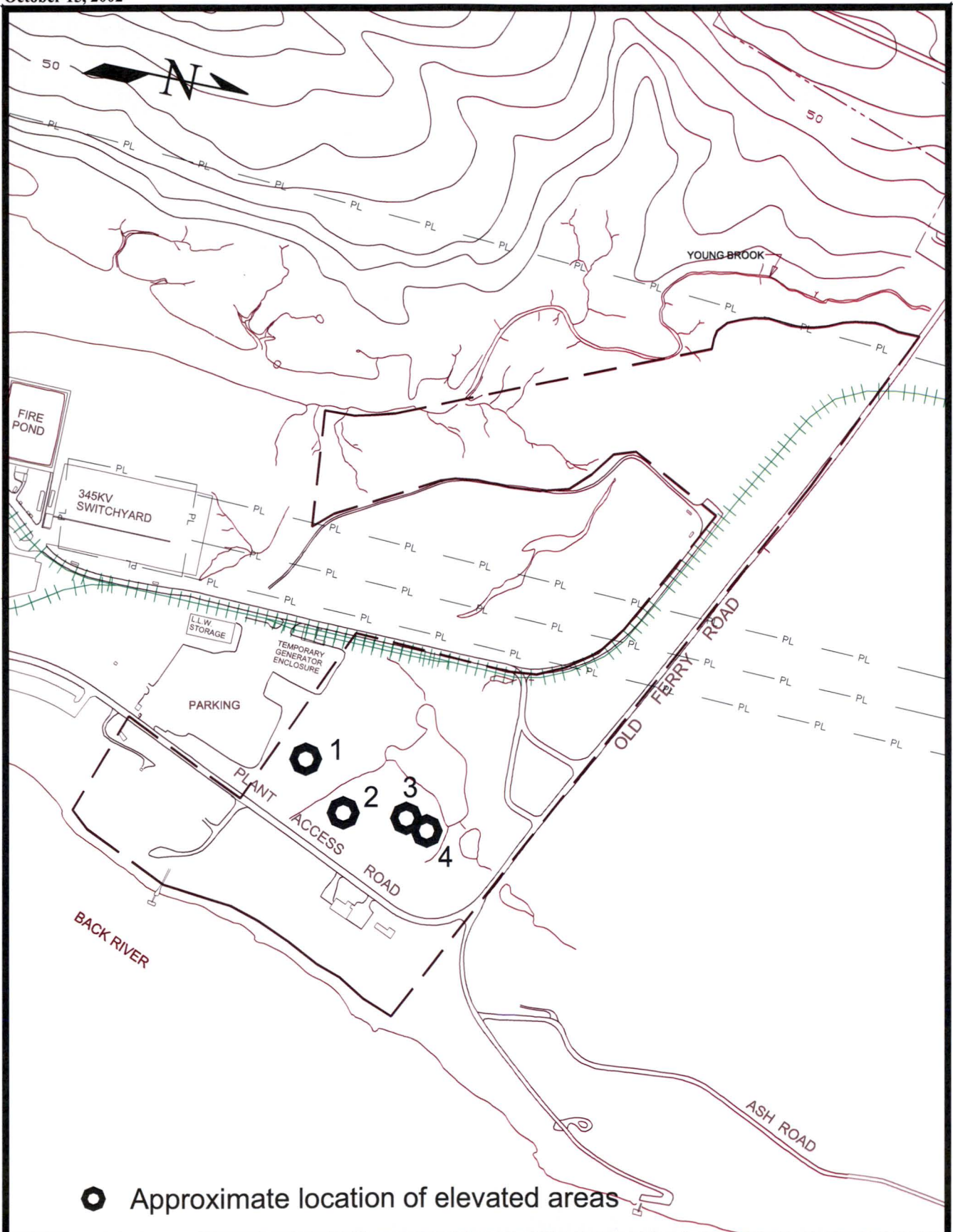




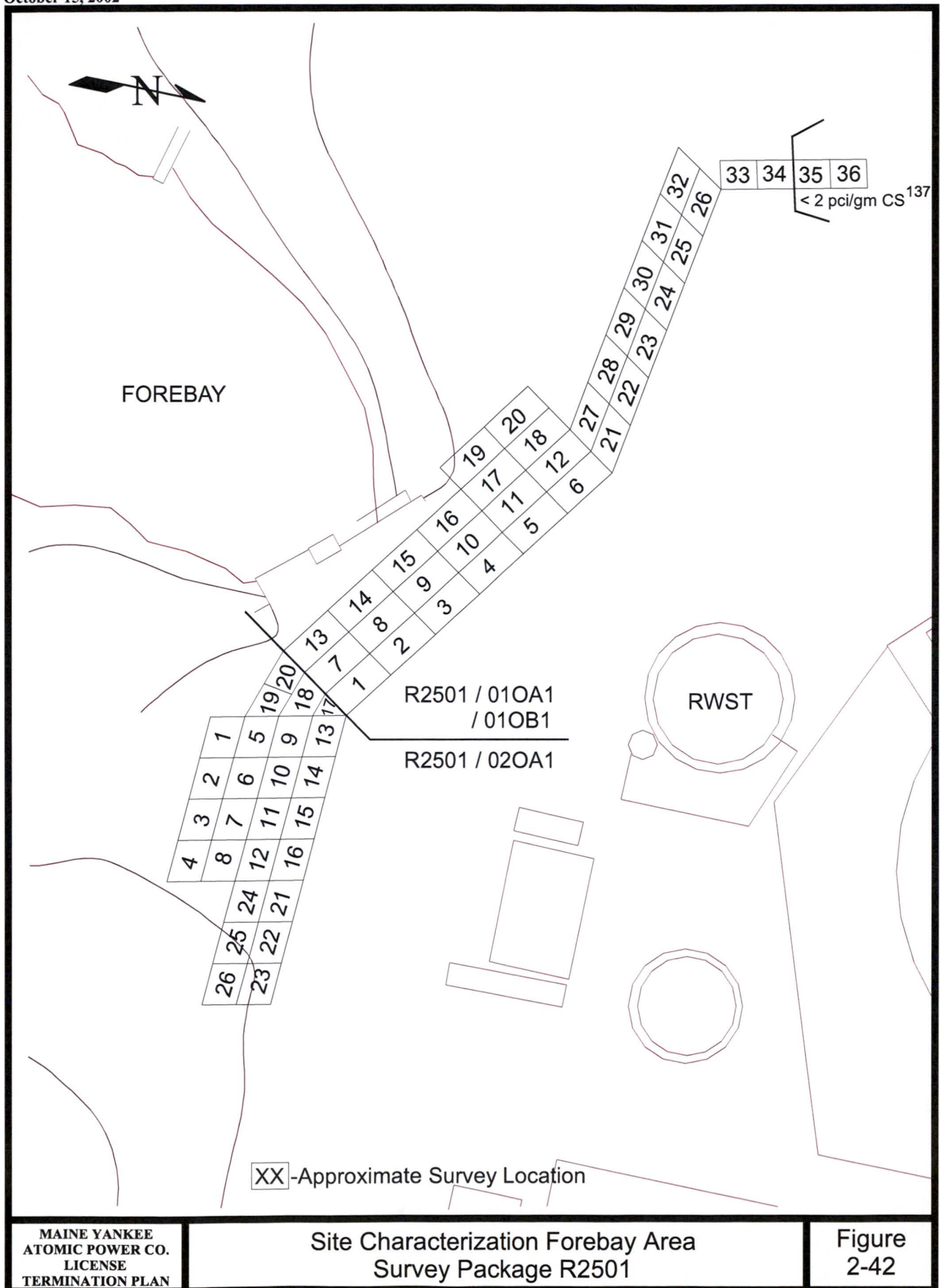


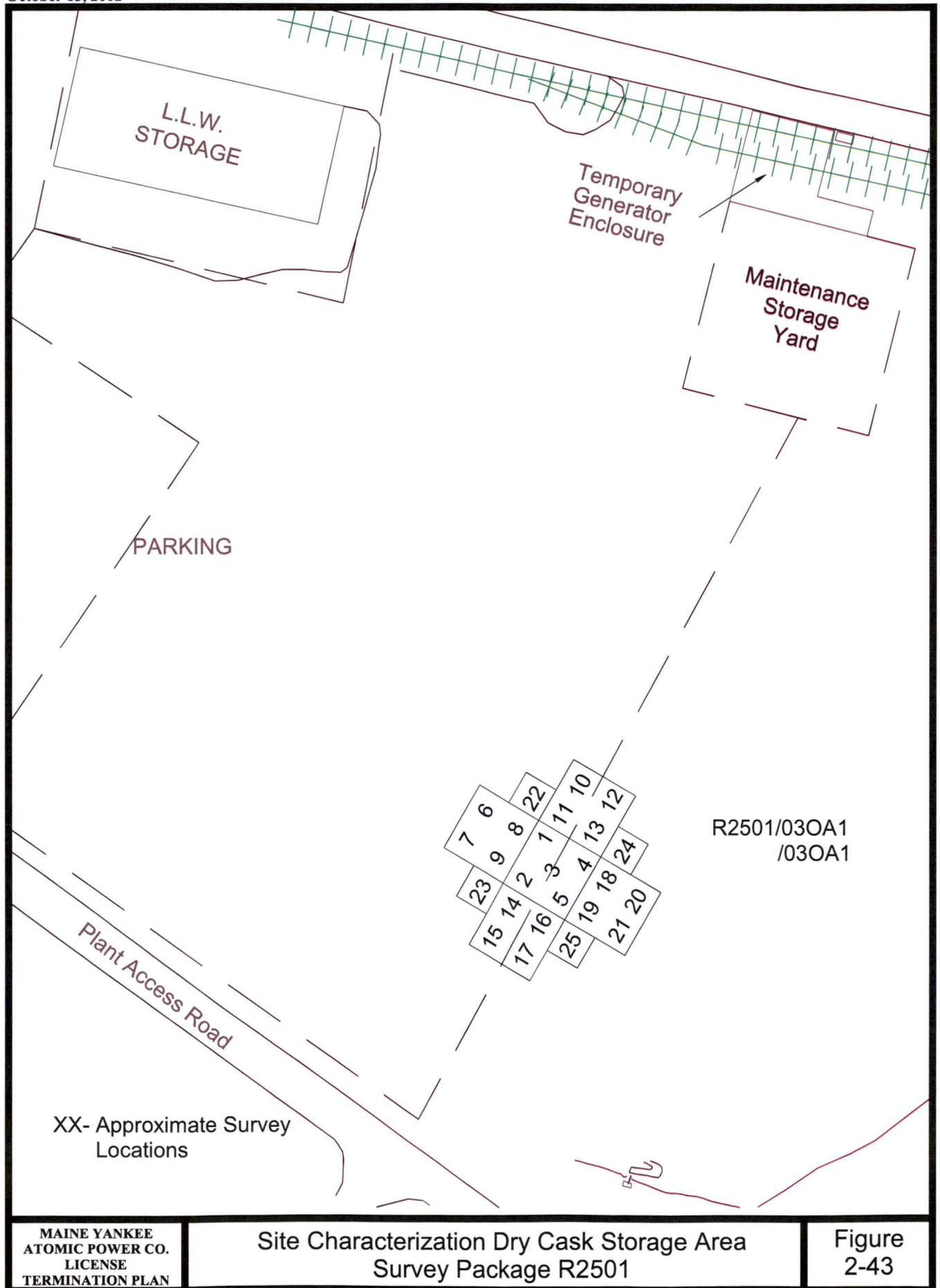


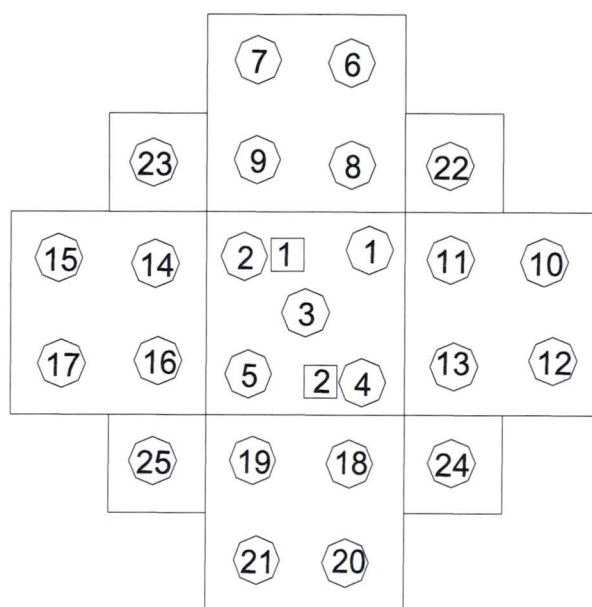










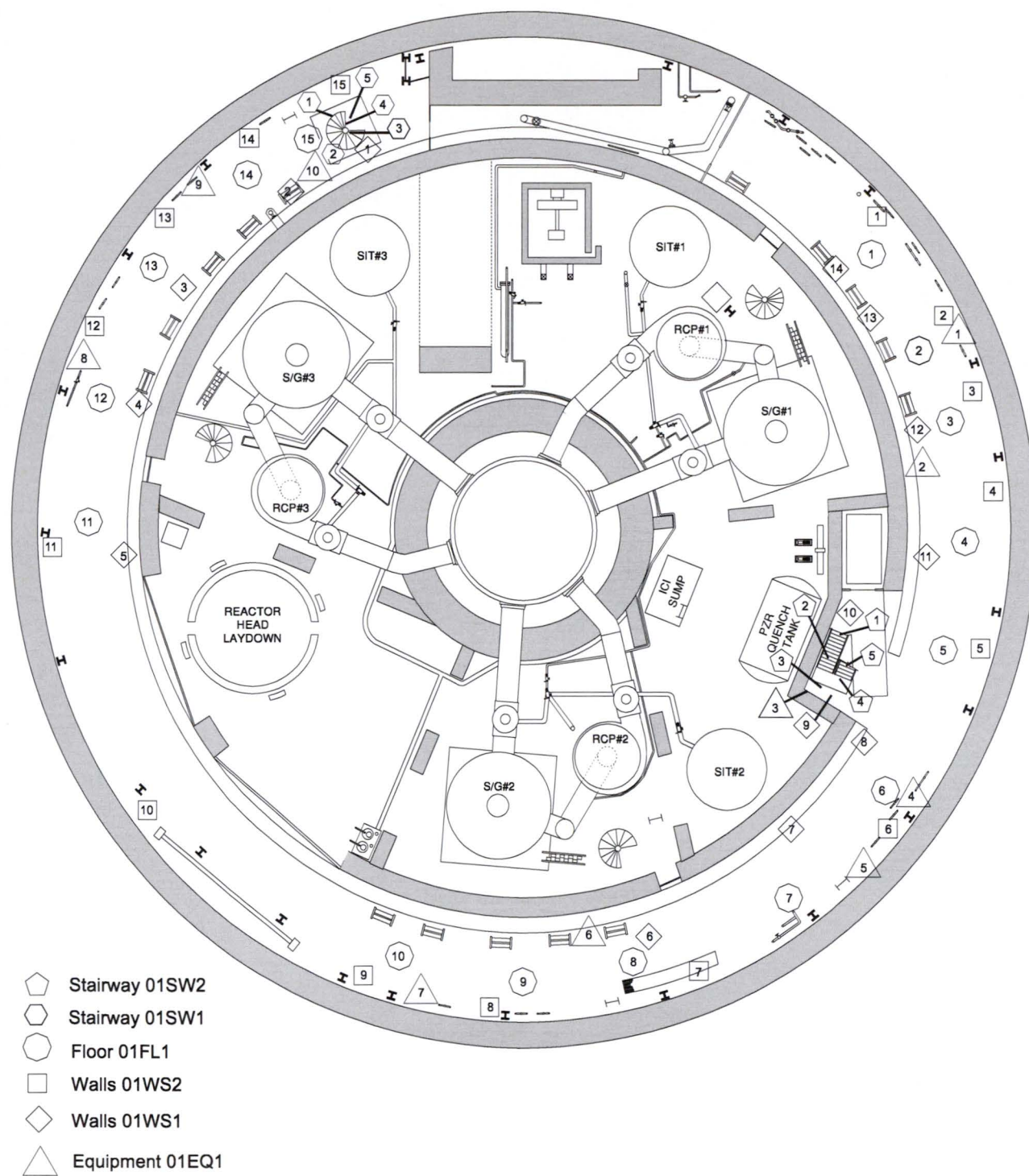


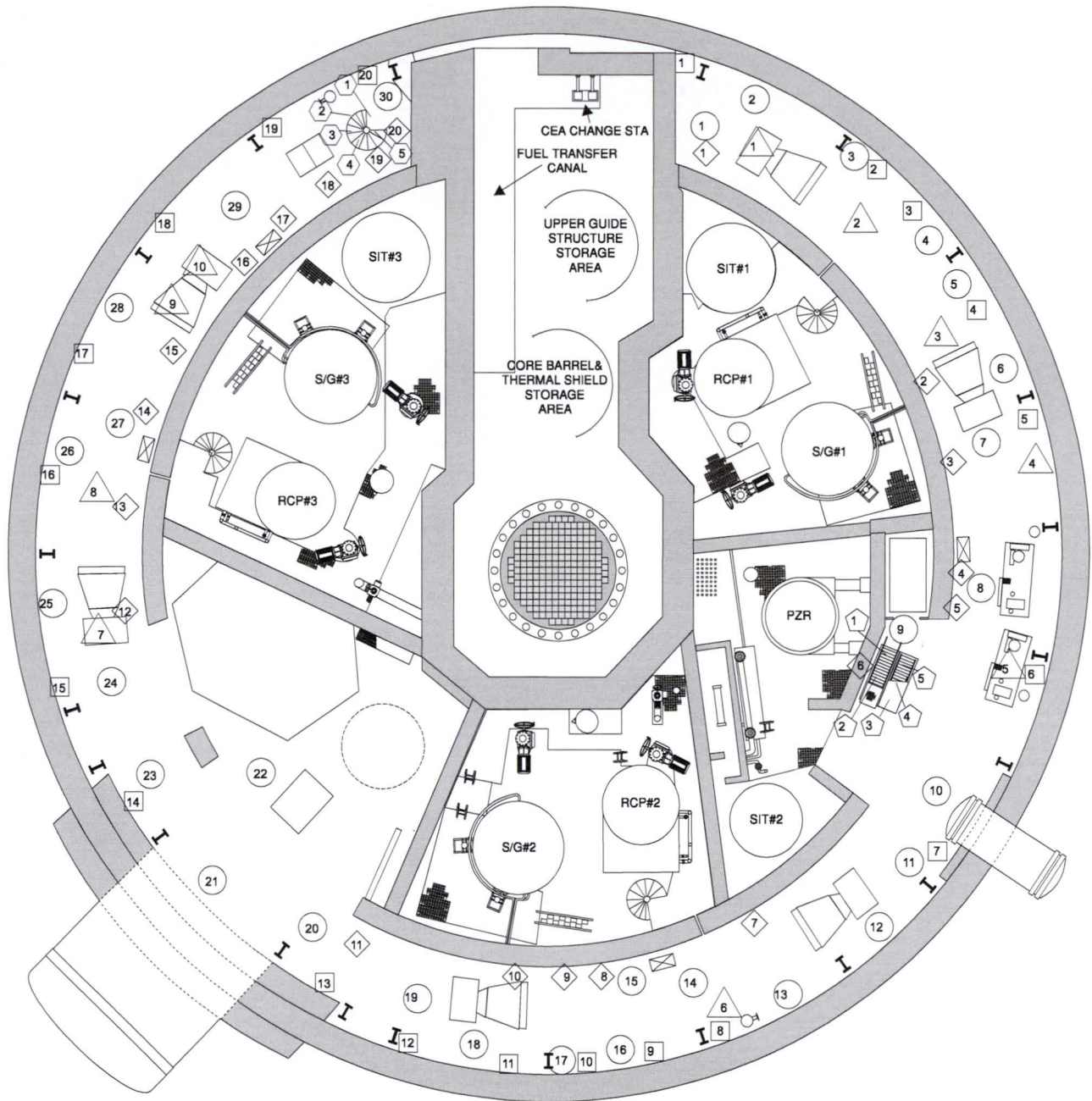


Dry Cask Storage Area

-  0 - 6" Soil Sample Location (Approximate)
-  6 - 12" Soil Sample Location (Approximate)







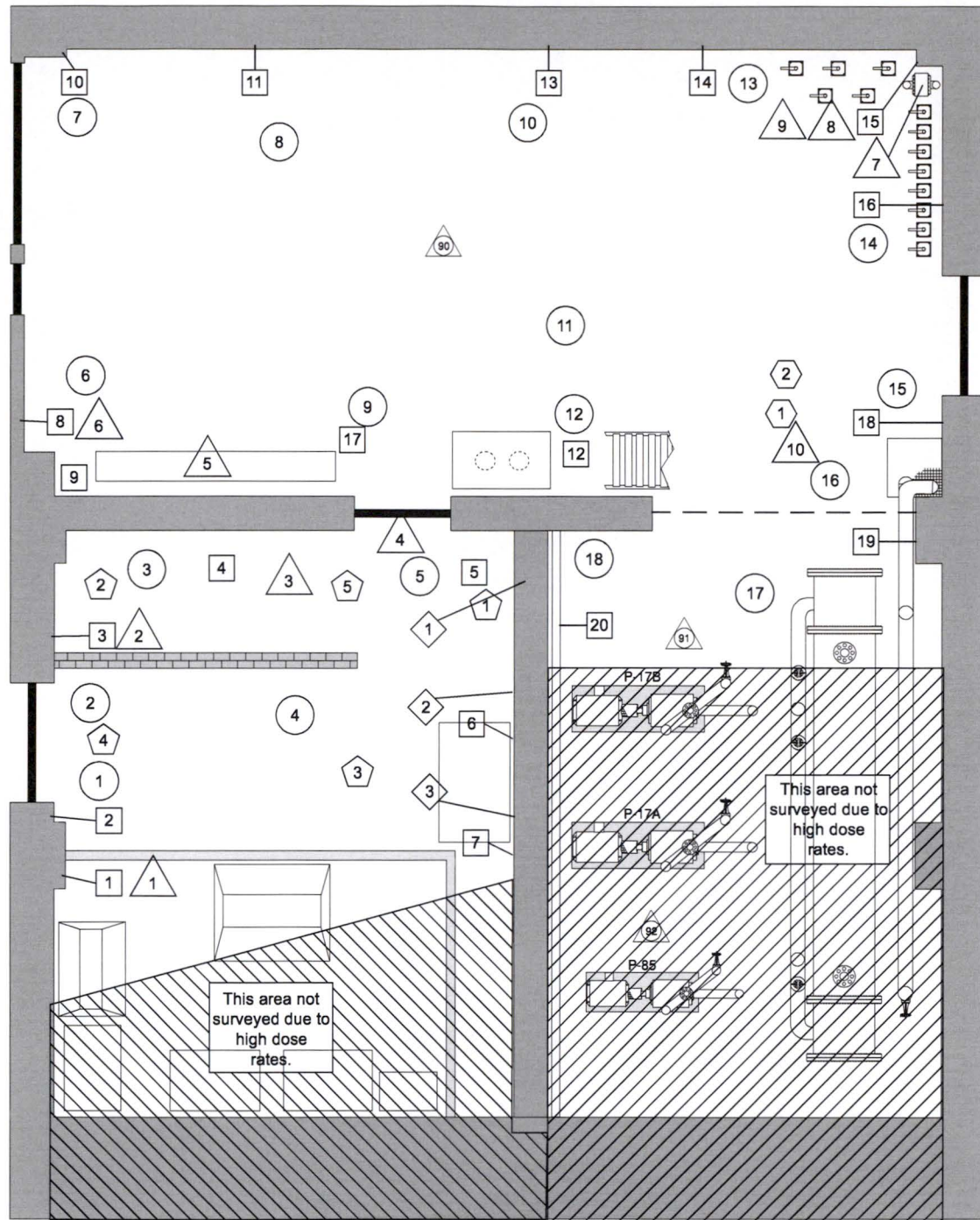
- XX NW Stair well 01SW2
- XX SW Stairwell 01SW1
- XX Equipment 01EQ1
- XX Outer Walls 01WS1
- XX Inner Walls 01WS2
- XX Floors 01FL1

MAINE YANKEE  
ATOMIC POWER CO.  
LICENSE  
TERMINATION PLAN

Site Characterization 20 ft Elevation  
Survey Package A0200

Figure  
2-46

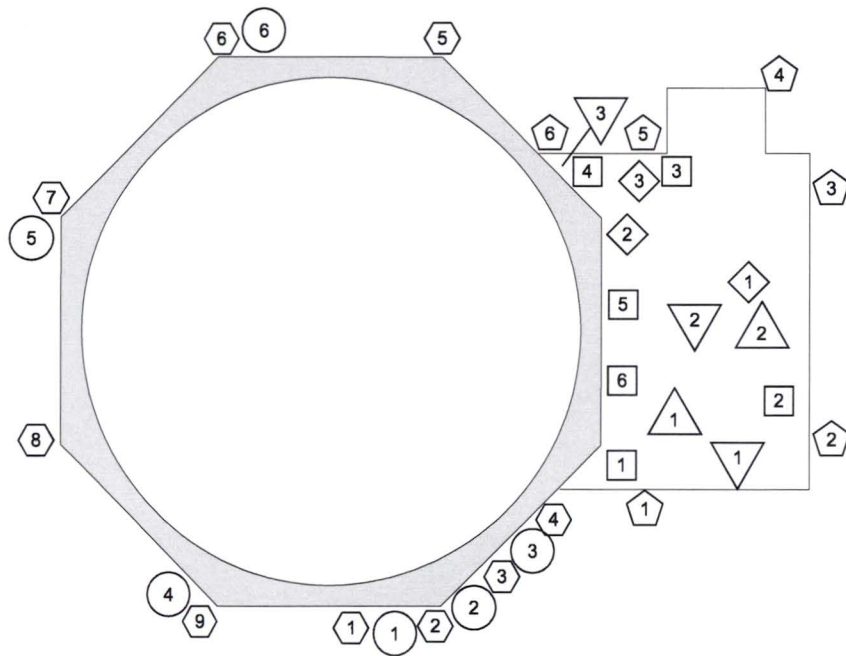











- XX Stair well
- XX Floor Drains
- XX Equipment 01EQ1
- XX Walls
- XX Floor Drain
- XX Floors

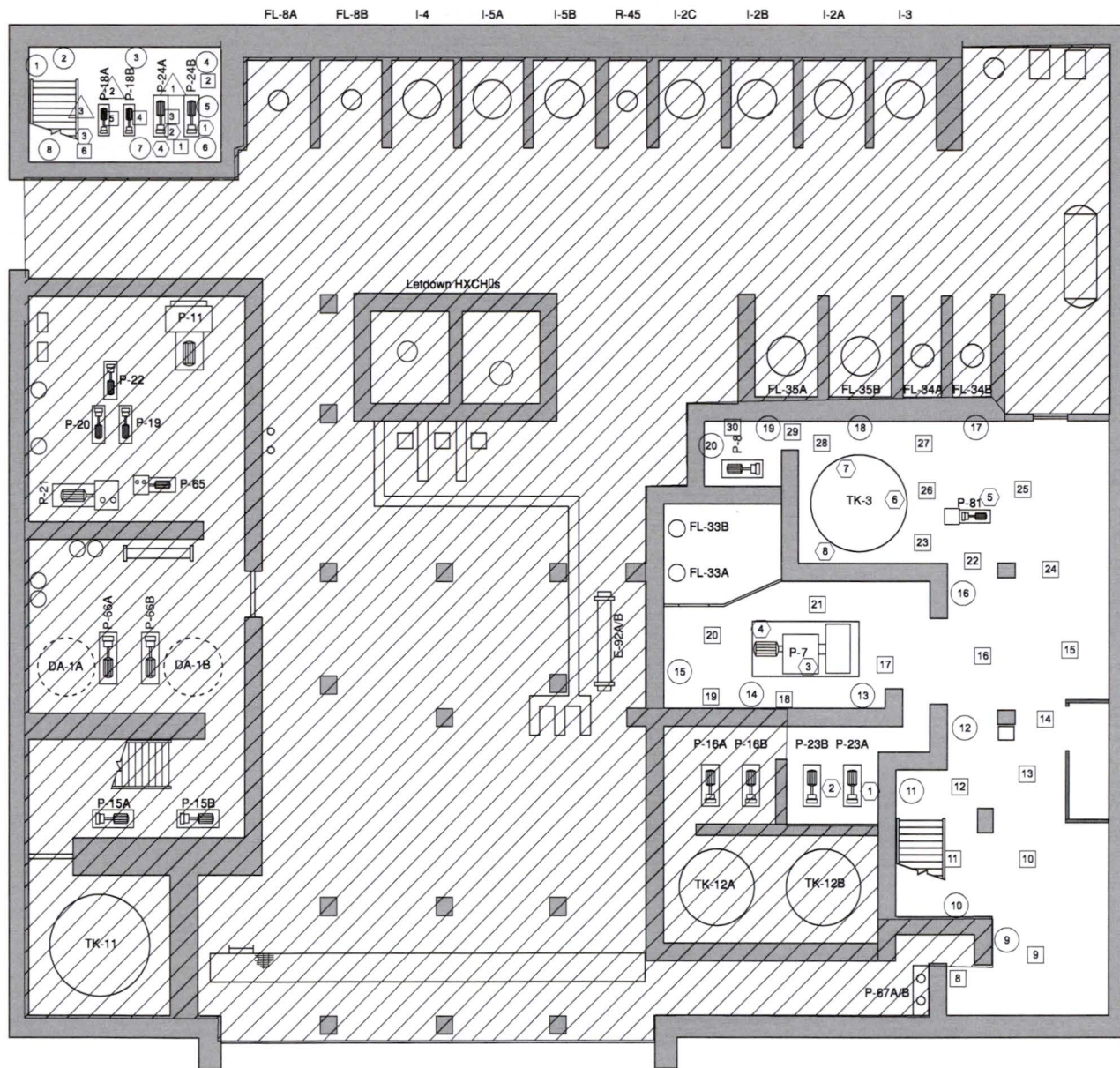


Spray Building



-  Tank Exterior 01WE1
-  Wall Exterior 02WE1
-  Ceiling 02CL1
-  Wall Interior 02WS1
-  Equipment 02EQ1
-  Structural Tank Supports 01SS1
-  Floor 02FL1

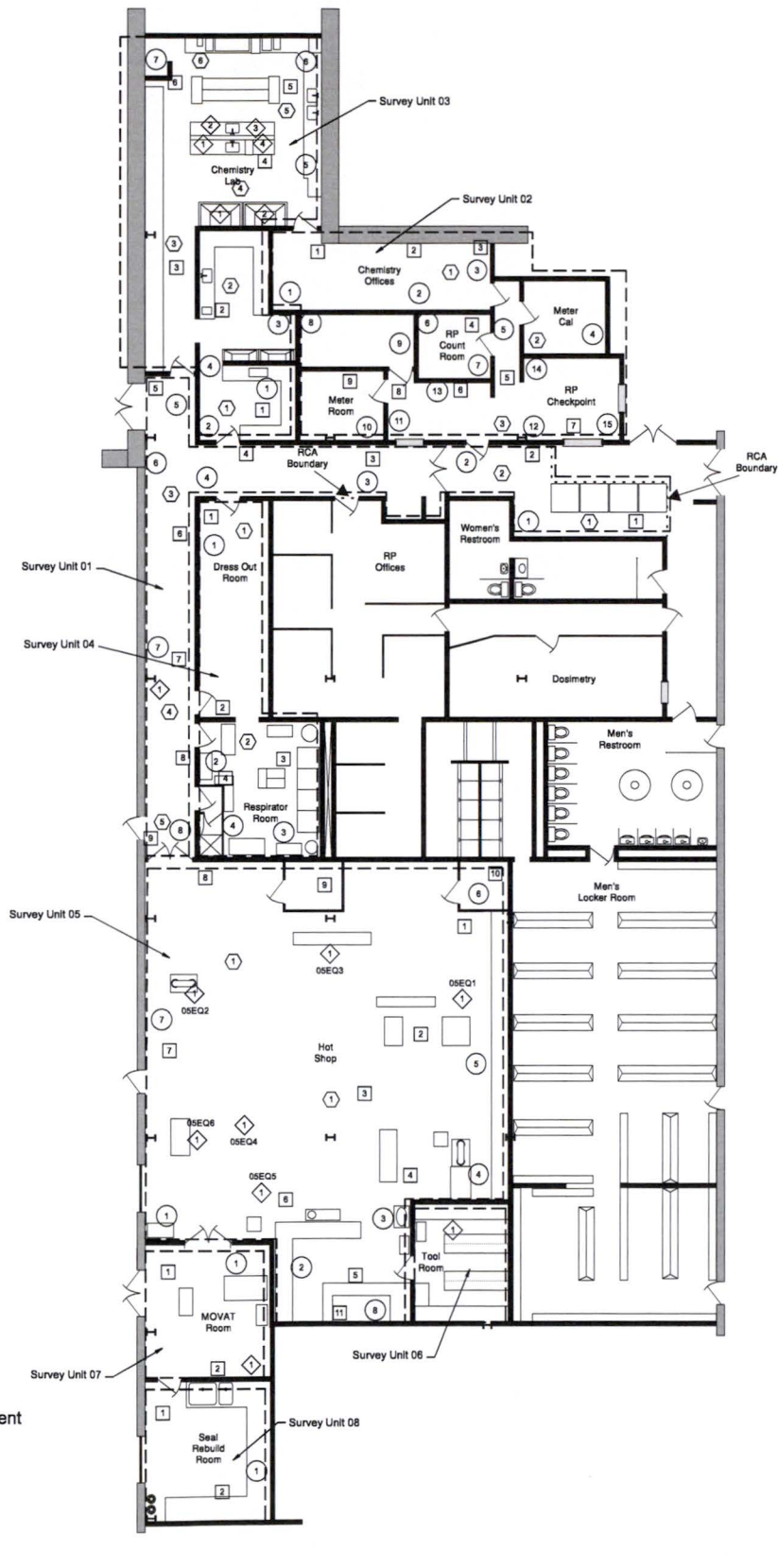




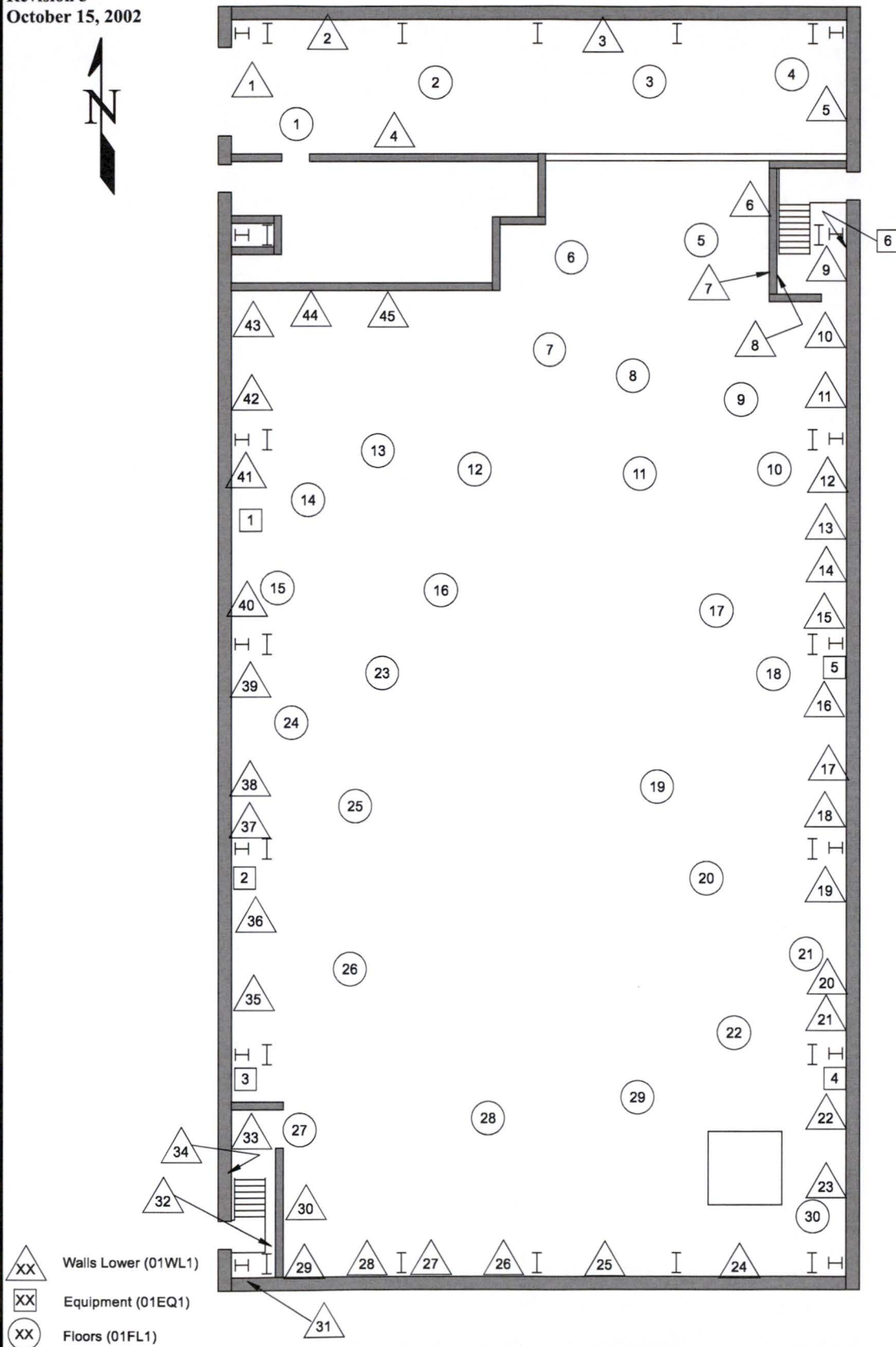
- XX Equipment
- XX Ceiling
- XX Floors
- XX Walls



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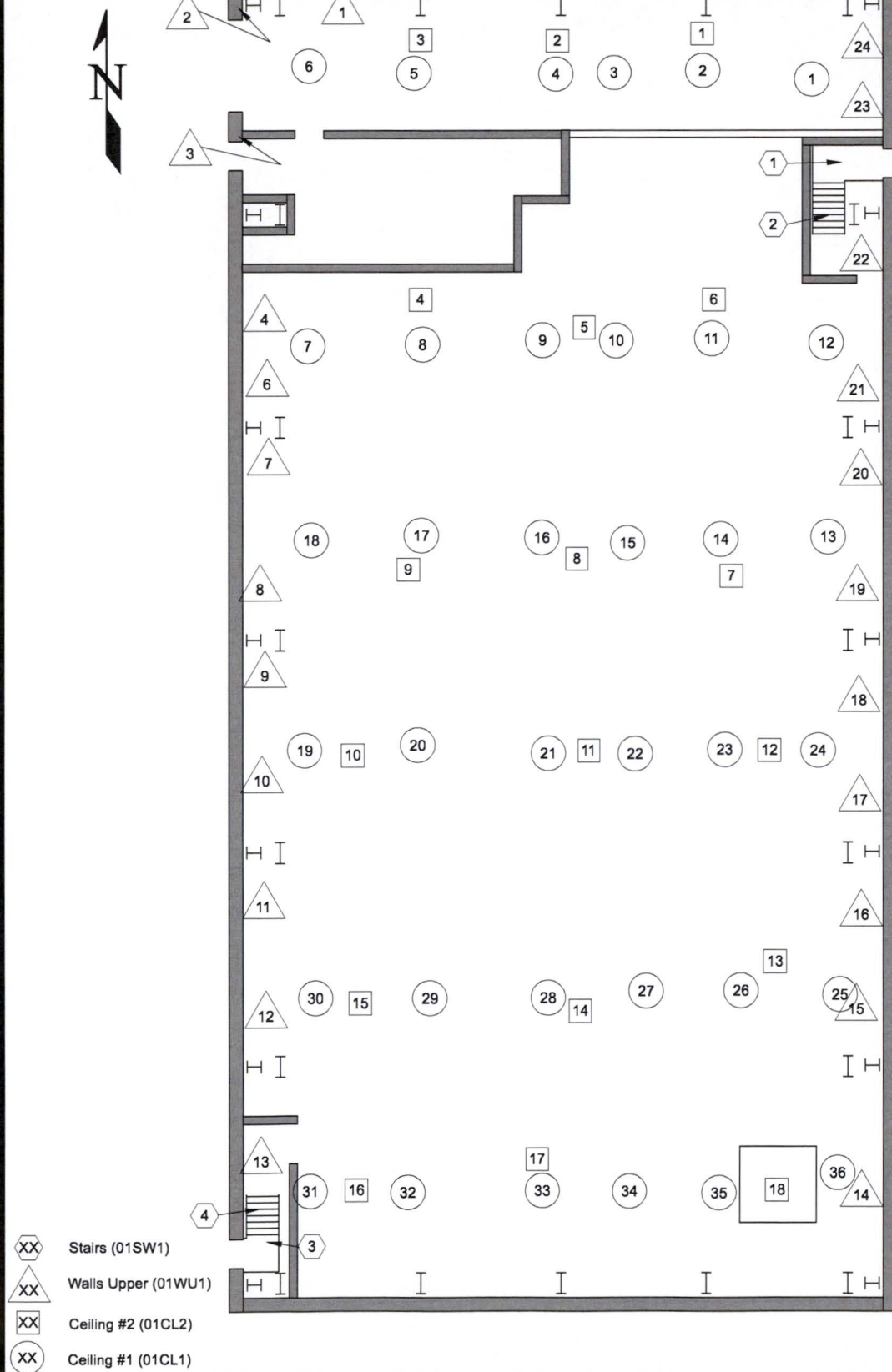


MAINE YANKEE  
ATOMIC POWER CO.  
LICENSE  
TERMINATION PLAN

Site Characterization Low Level Waste Storage Building 21 ft  
Survey Package A1100

Figure  
2-51

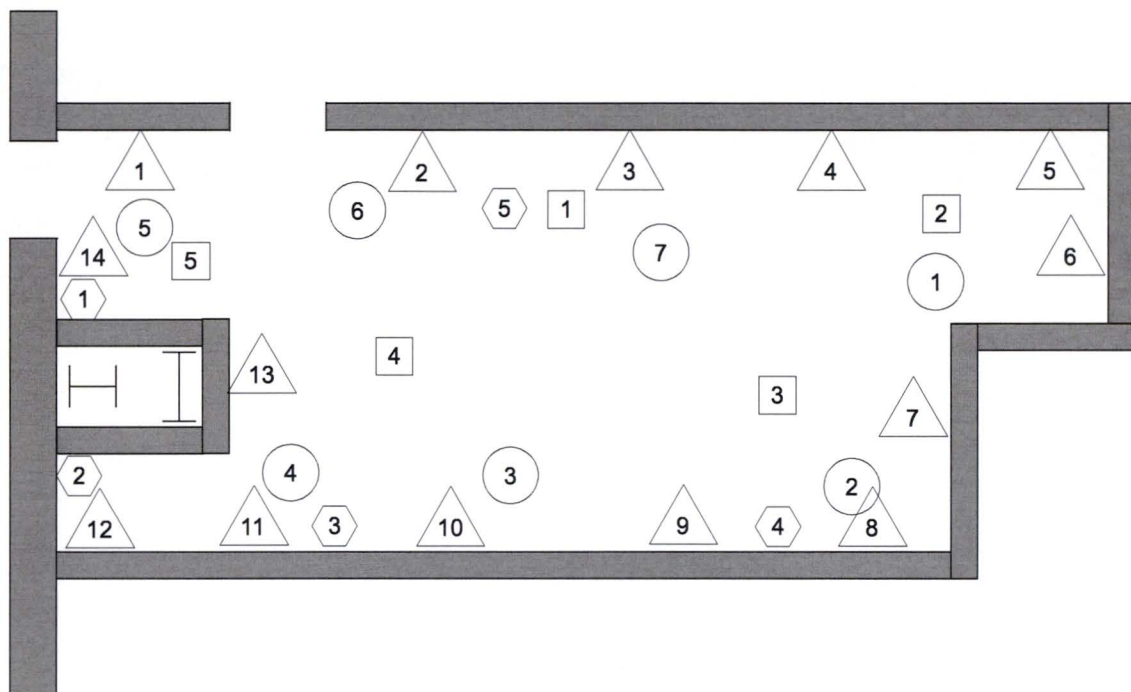
MYAPC License Termination Plan  
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MAINE YANKEE  
ATOMIC POWER CO.  
LICENSE  
TERMINATION PLAN

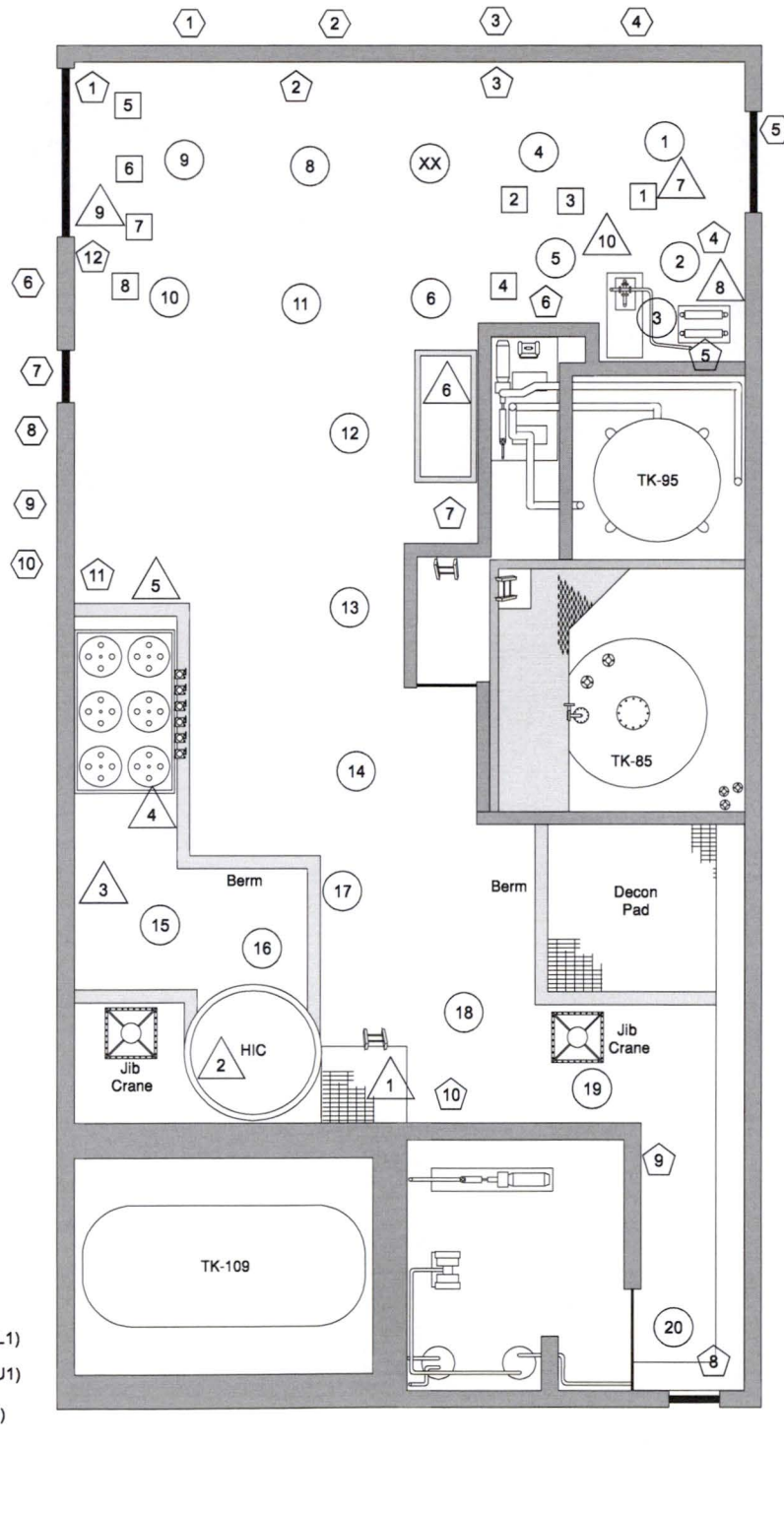
Site Characterization Low Level Waste Storage Building 21 ft  
Survey Package A1100

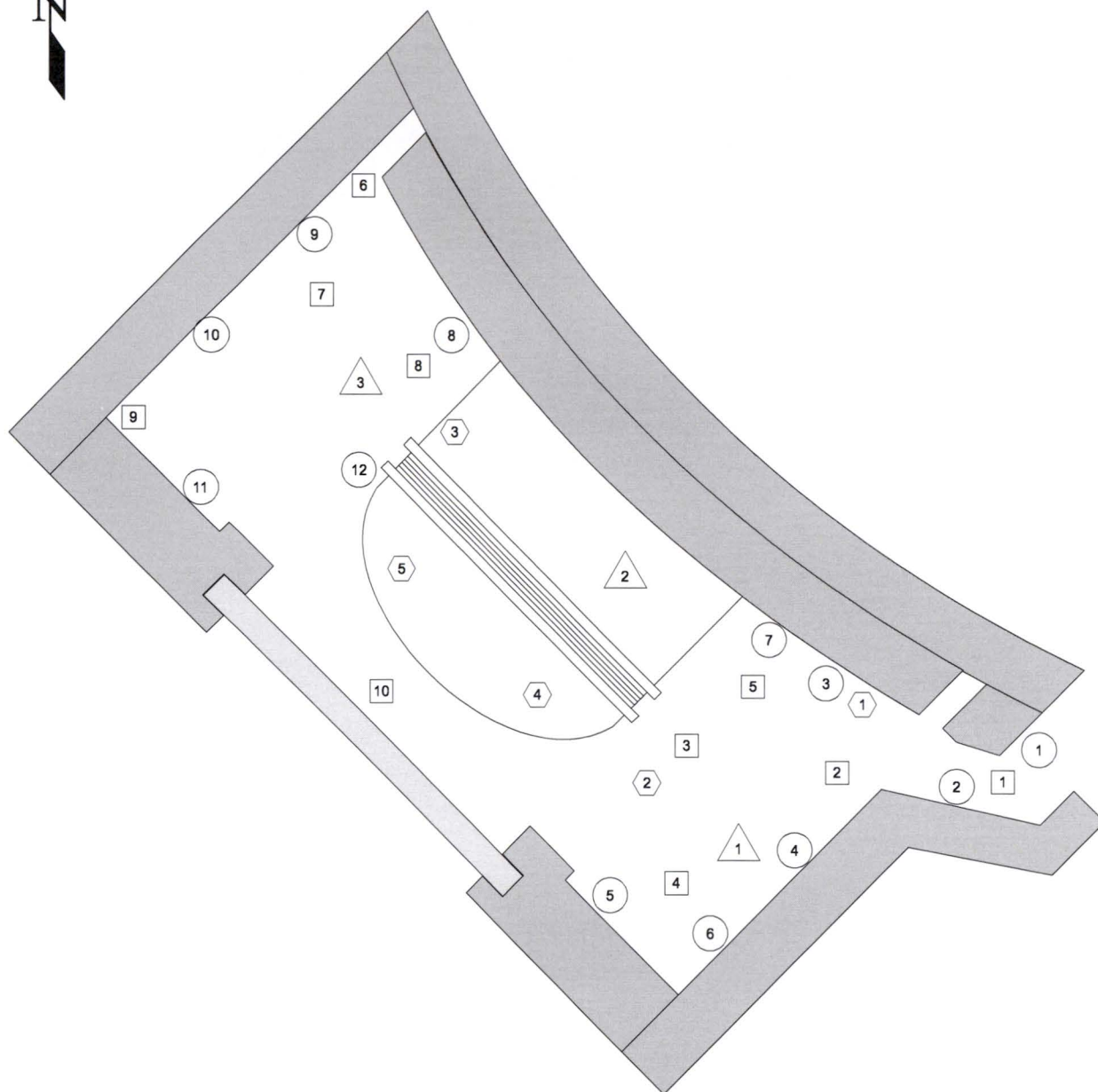
Figure  
2-52



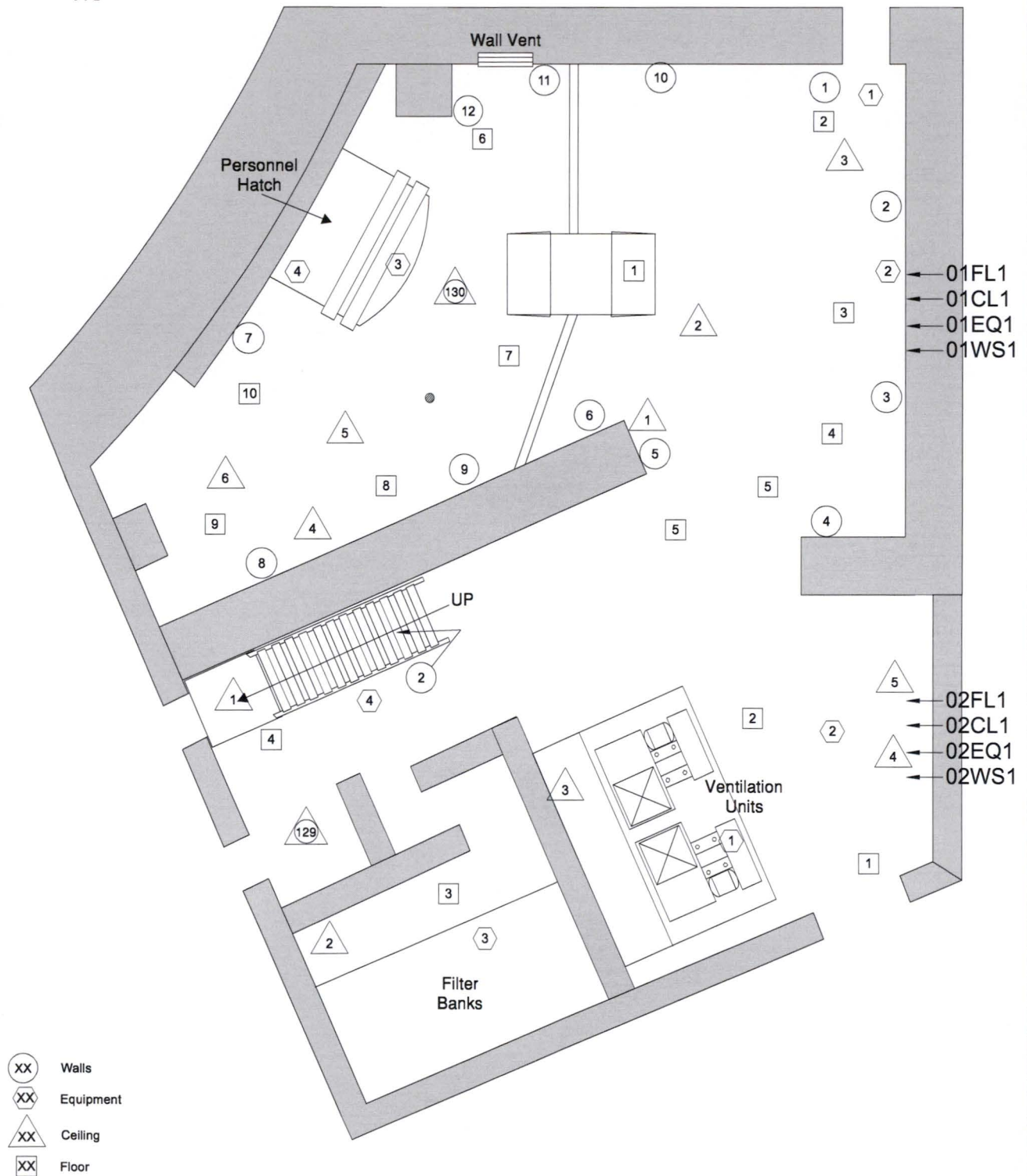
-  Equipment (02EQ1)
-  Walls (01WS1)
-  Ceiling #2 (02CL1)
-  Floor (02FL1)

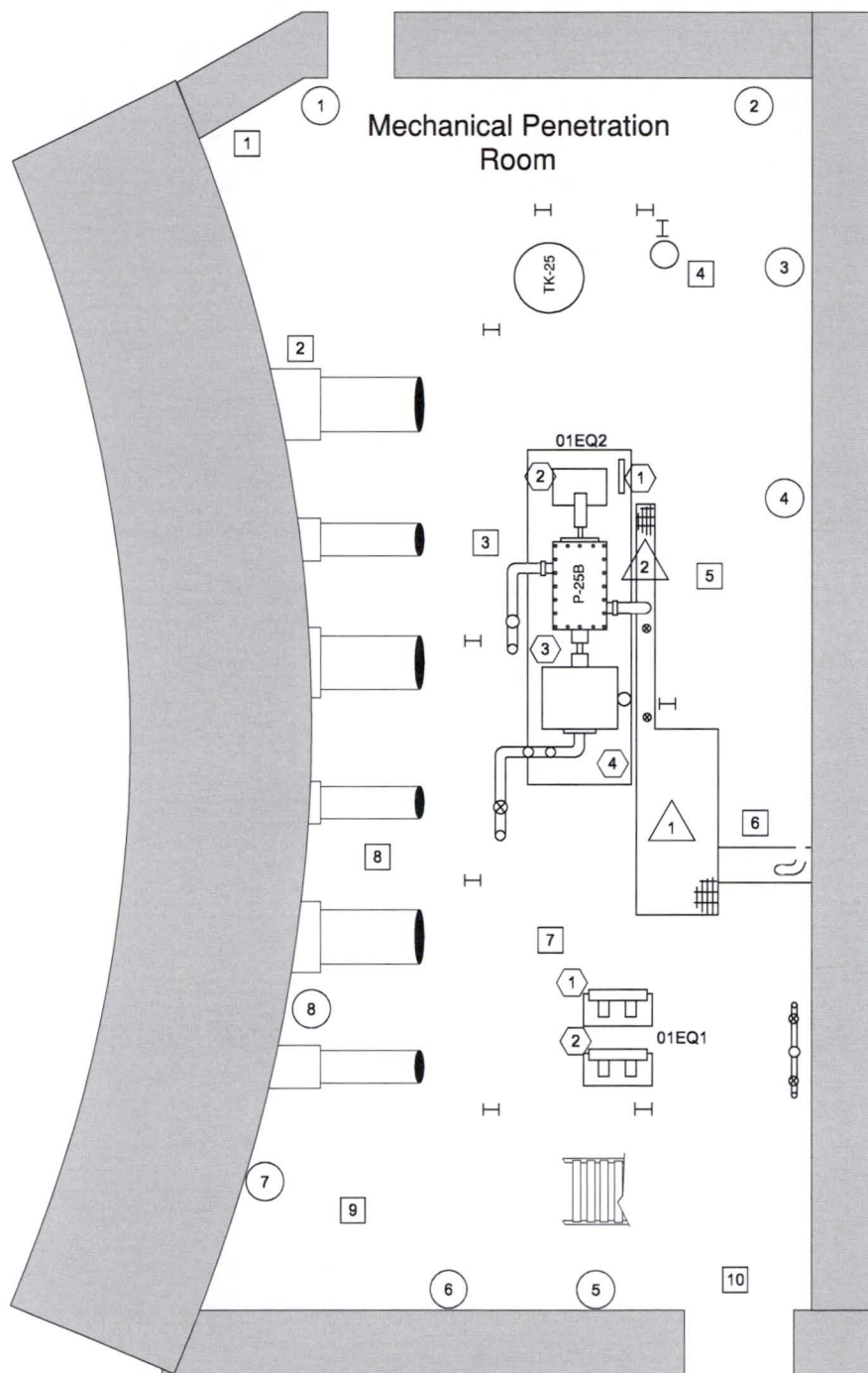






- (XX) Walls (01WS1)
- (XX) Equipment (01EQ1)
- (XX) Ceiling (01CL1)
- (XX) Floor (01FL1)





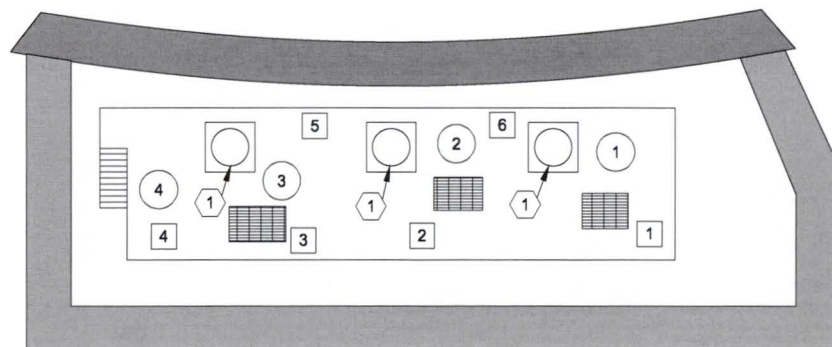
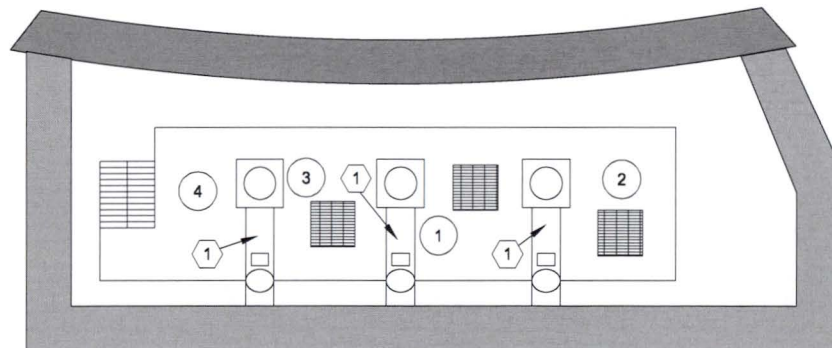
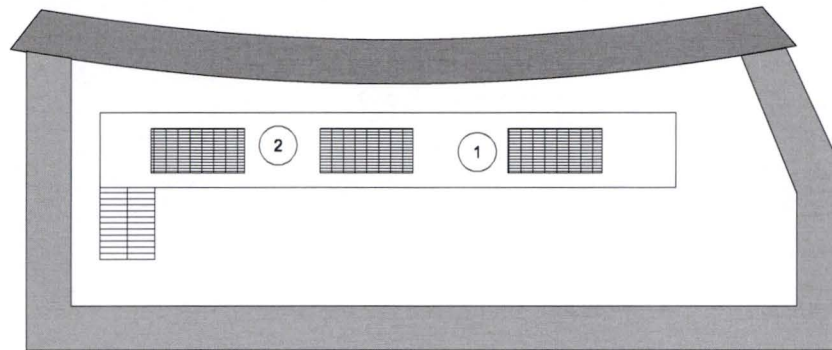
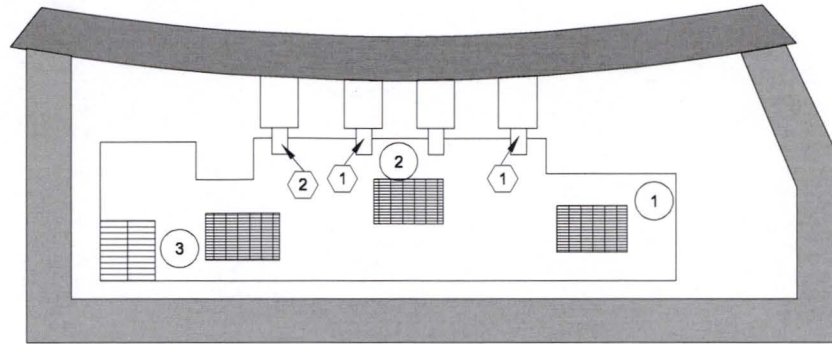
- (XX) Walls
- (XX) Equipment
- (XX) Floor Drain
- (XX) Floor



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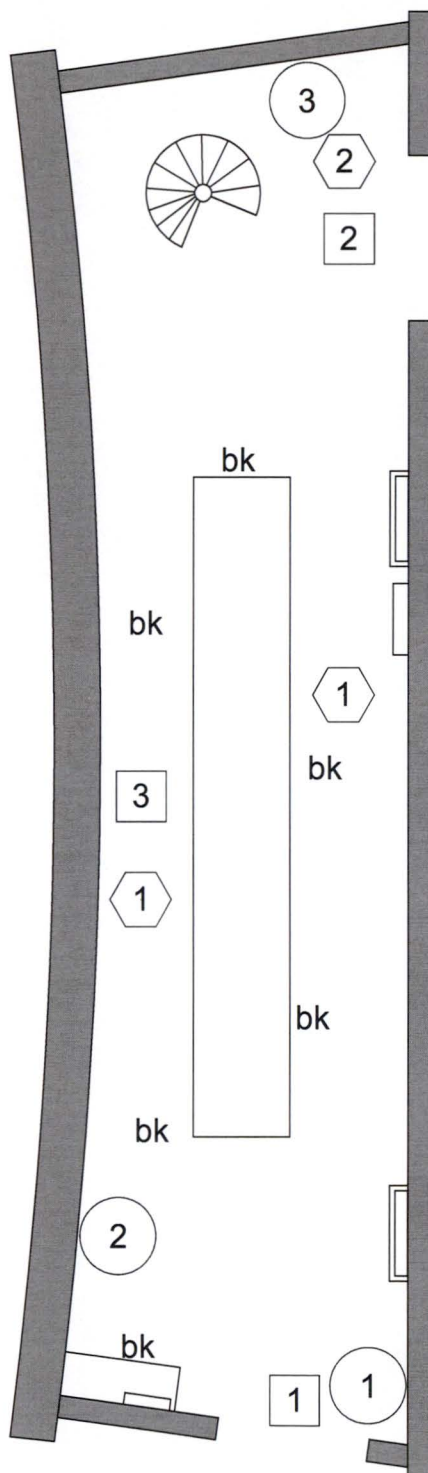


- XX Equipment
- XX Ceiling
- XX Floor

MAINE YANKEE  
ATOMIC POWER CO.  
LICENSE  
TERMINATION PLAN

Site Characterization Mechanical Penetration Room  
Elevations 2, 3, 4, and 5 Survey Package A1500

Figure  
2-58

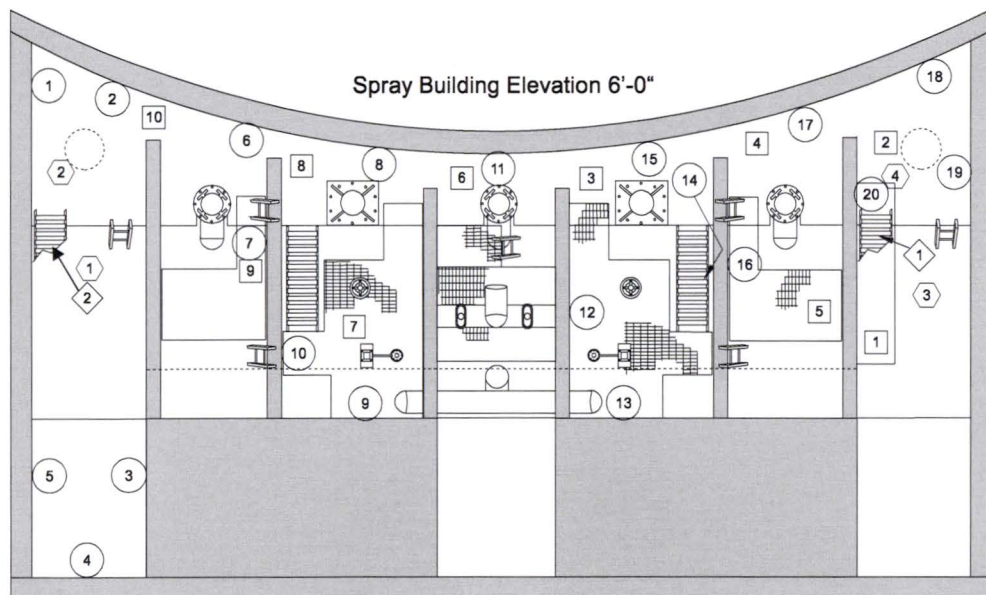
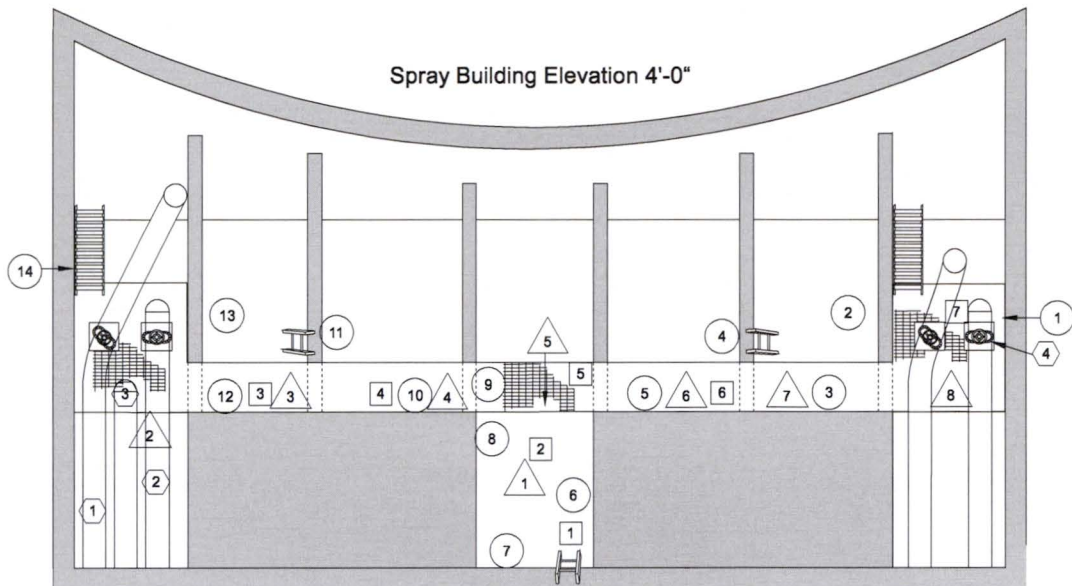







bk Background

XX Equipment

XX Floor

XX Walls

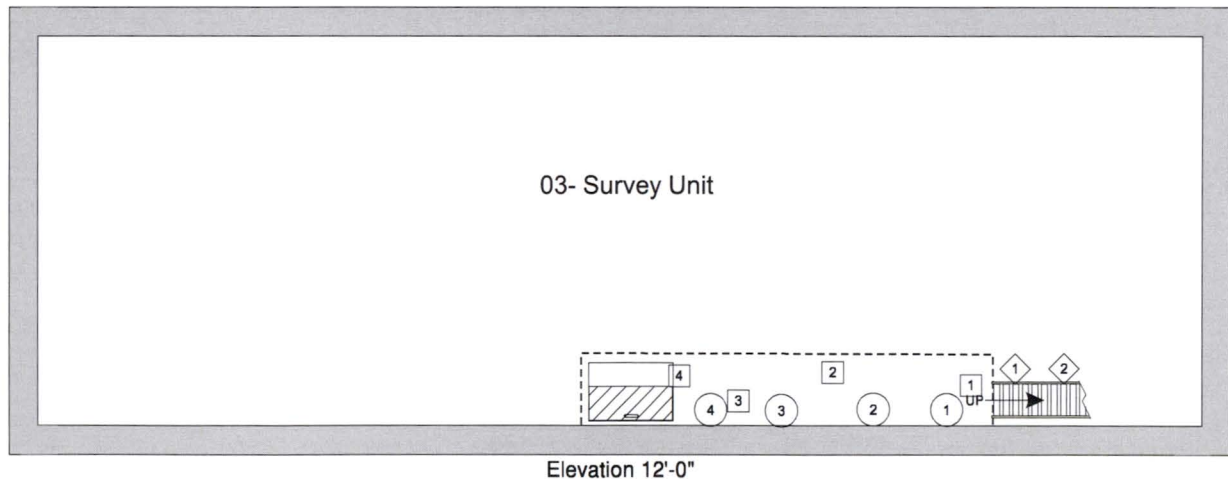
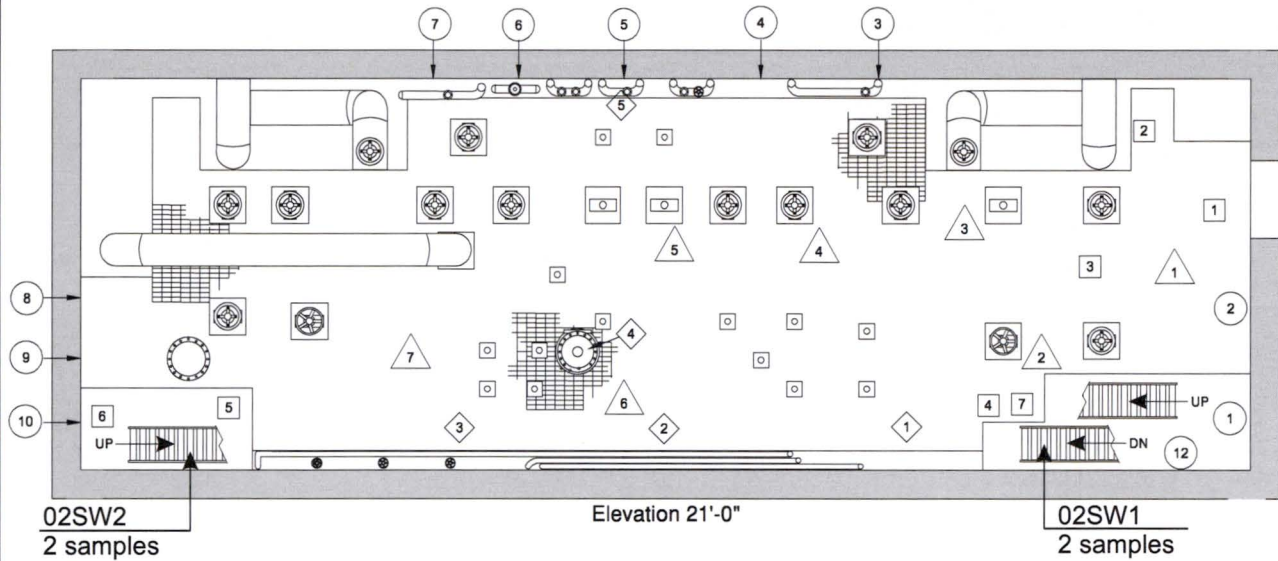


-  Walls
-  Equipment
-  Ceiling
-  Floor
-  Stairs

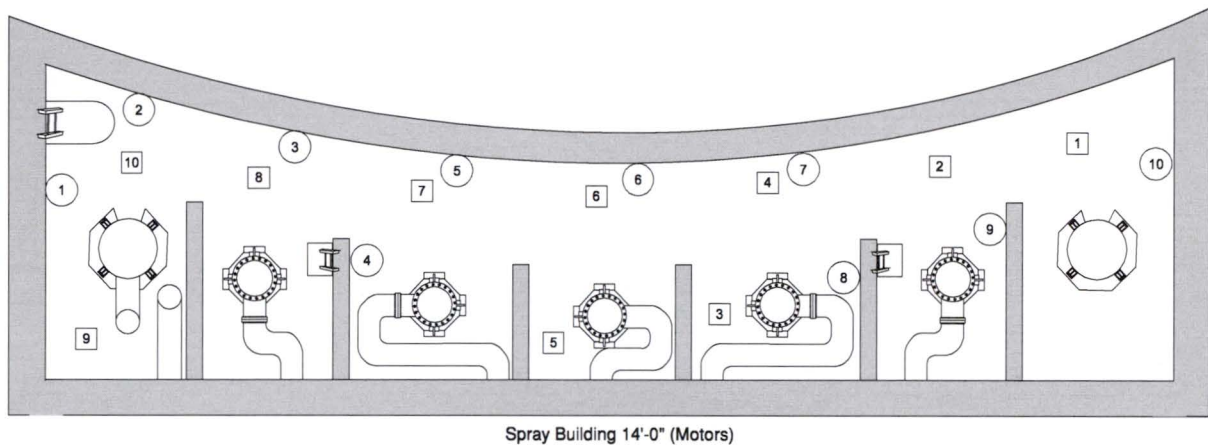




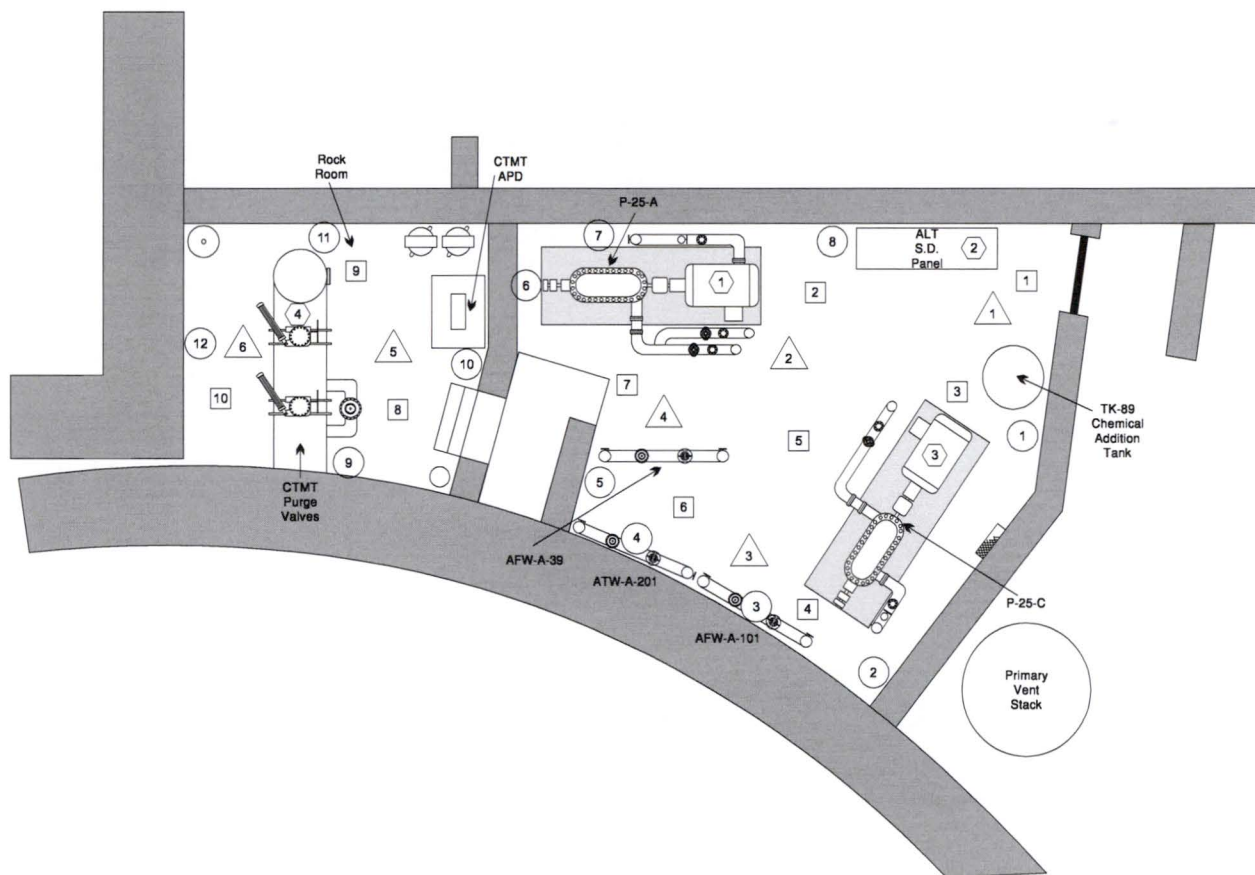
02FL1- Floor  
02WS1- Walls  
02EQ1- Equipment  
02CL1- Ceiling



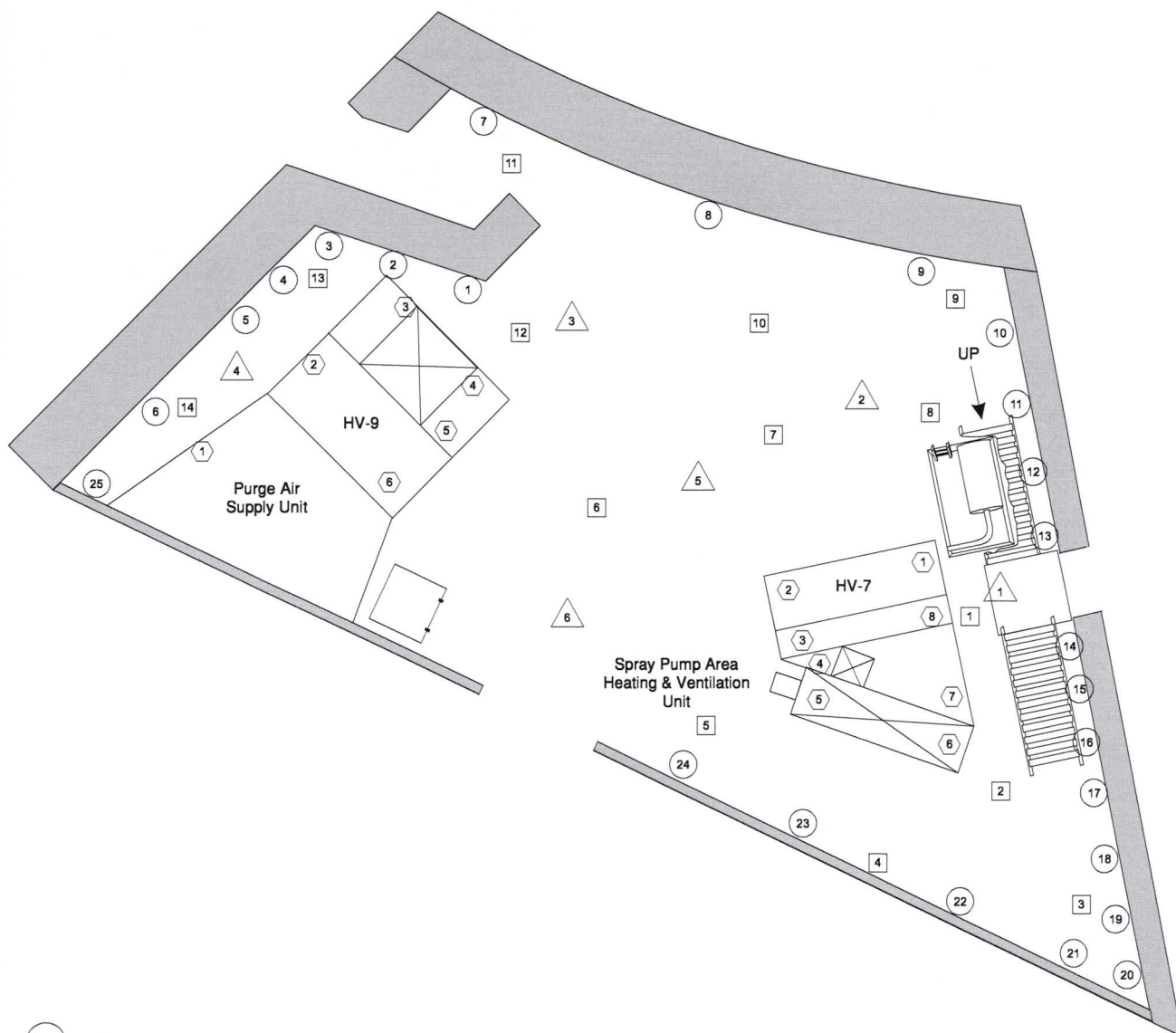
- Walls 03WS1
- Ceiling 03CL1
- Floor 03FL1
- Stairs 03SW1
- Floor Opening



- ⊗ Walls
- ⊠ Floor

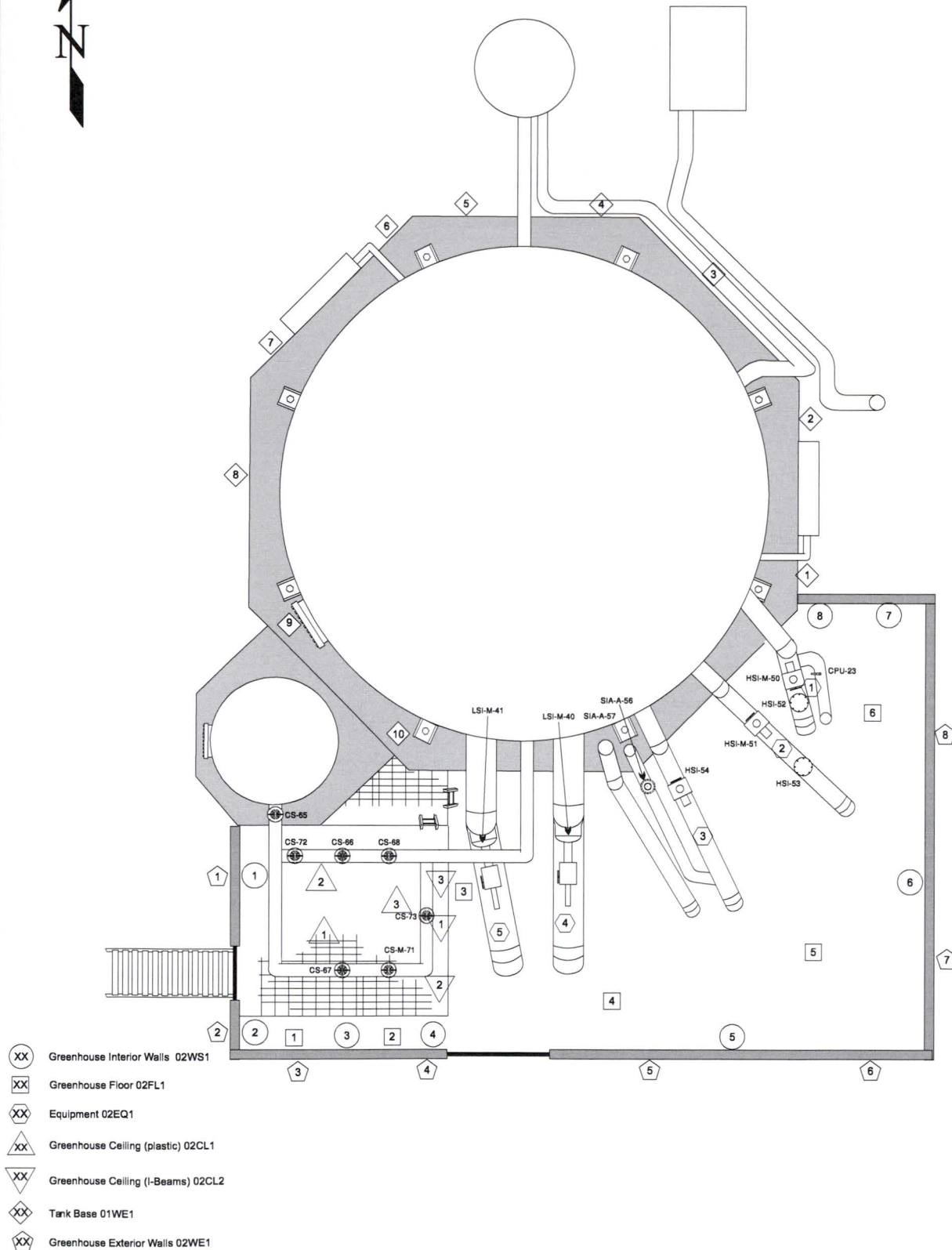


- (XX) Walls 01WS1
- (XX) Floor 01FI1
- (XX) Equipment 01EQ1
- (XX) Ceiling 01CL1

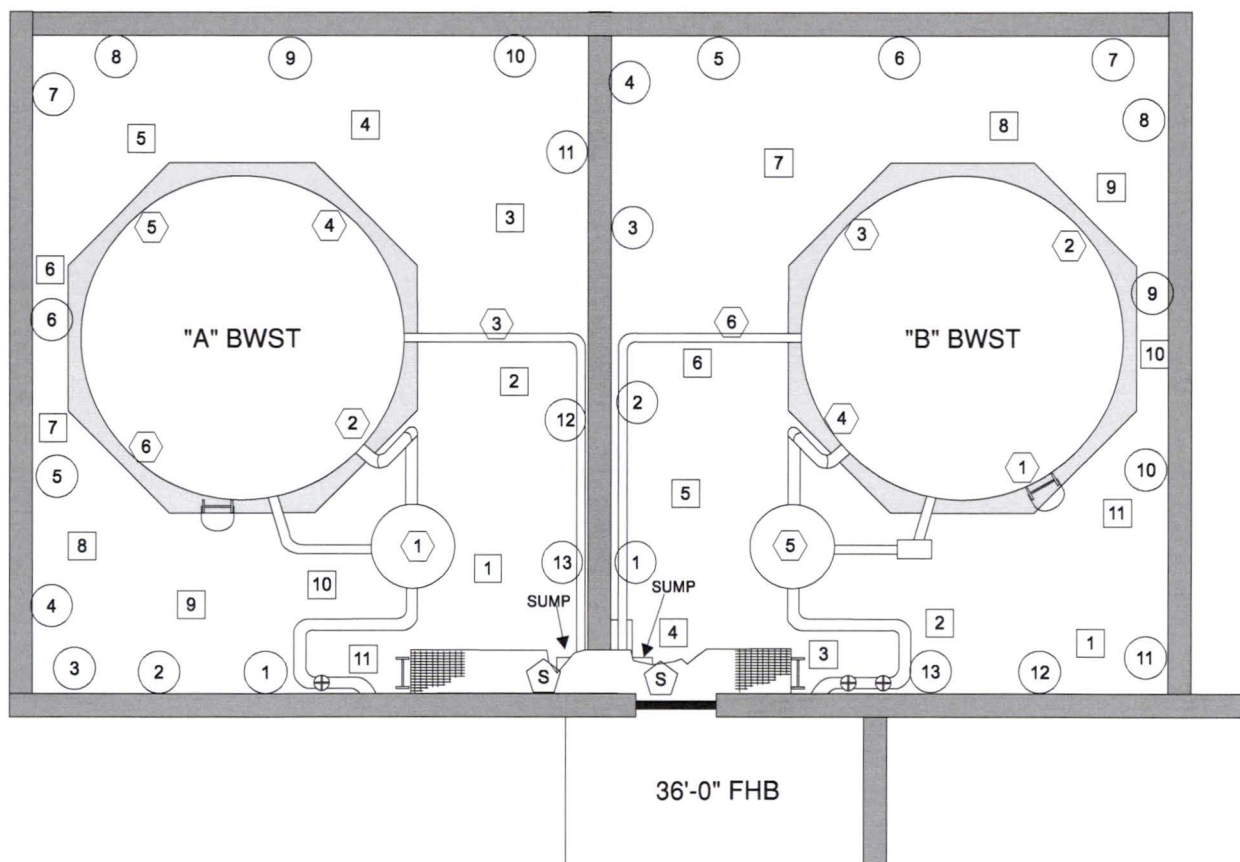


- XX Walls
- XX Floor
- XX Equipment
- XX Ceiling

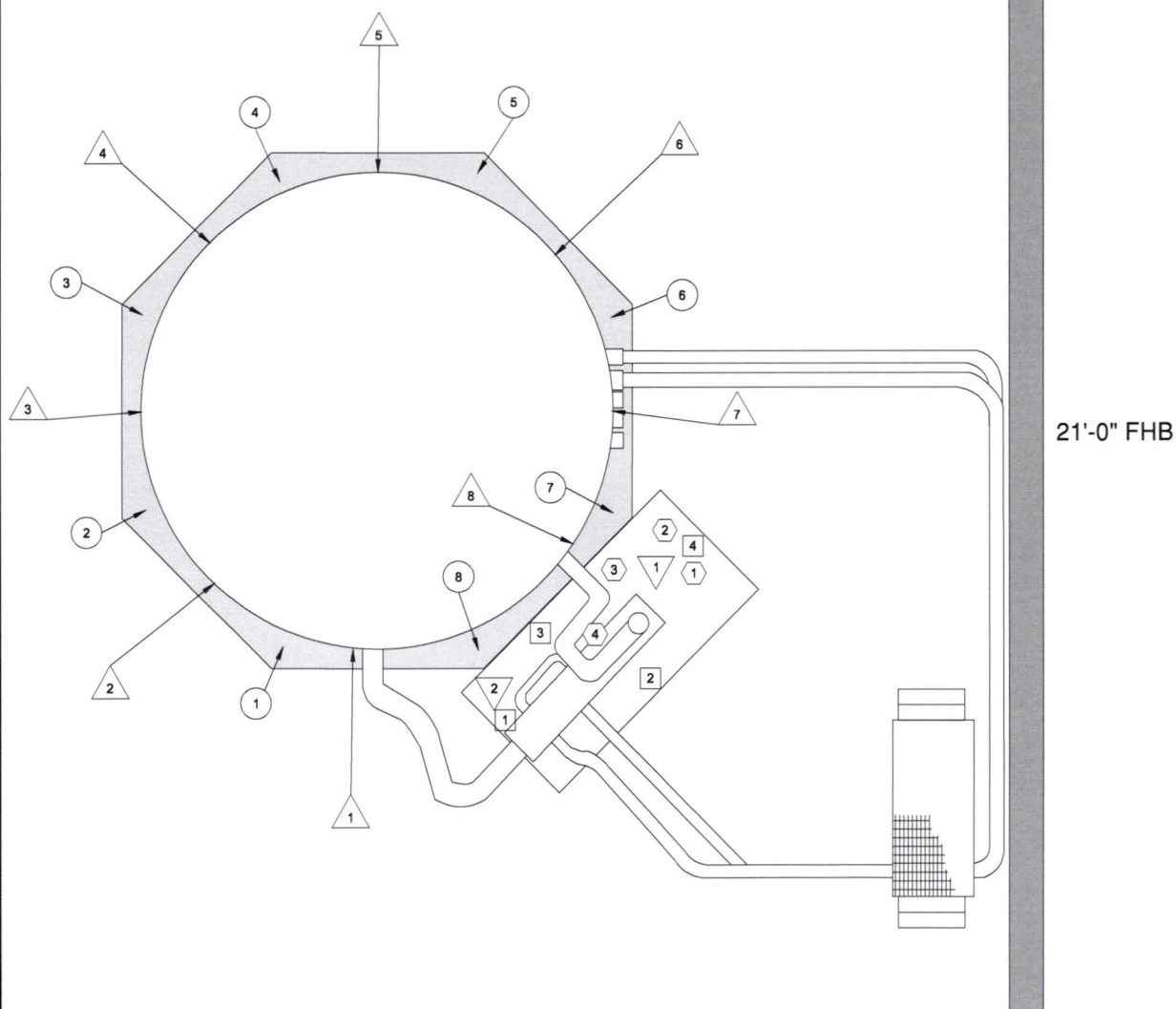






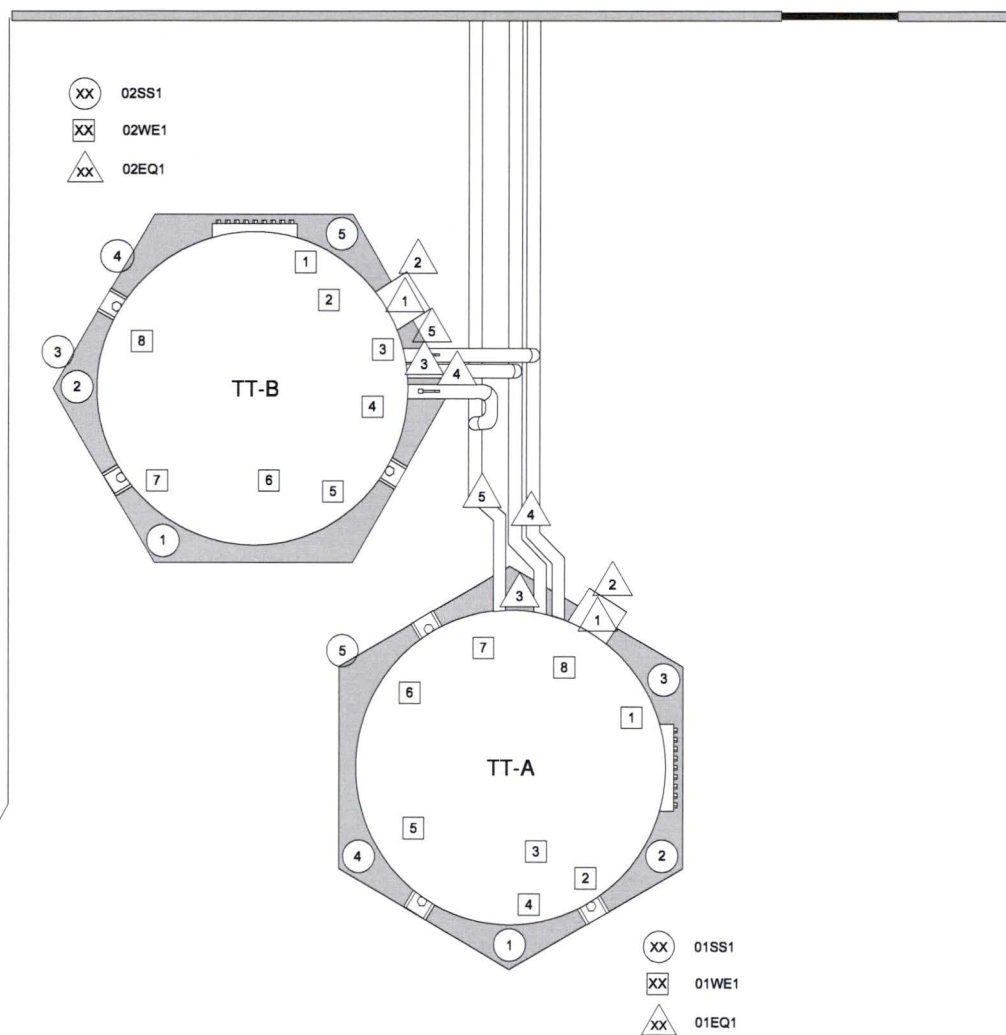


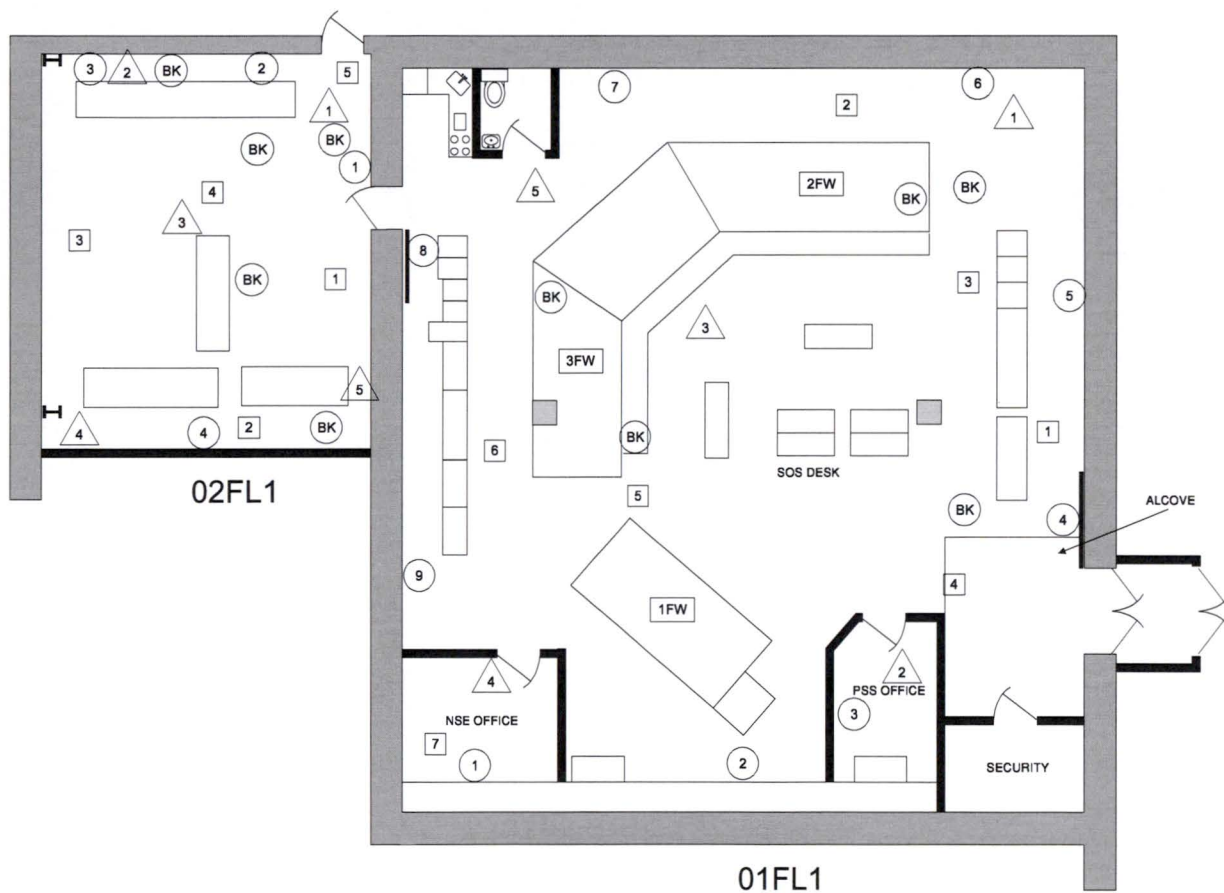
- (XX) Wall
- (XX) Floor
- (XX) Equipment
- (XX) Sump



- (XX) Tank Base 01SS1
- [XX] Shed Wall Inside 02WS1
- (XX) Equipment 02EQ1
- (XX) Tank Outside 01WE1
- (XX) Shed Ceiling 02CL1

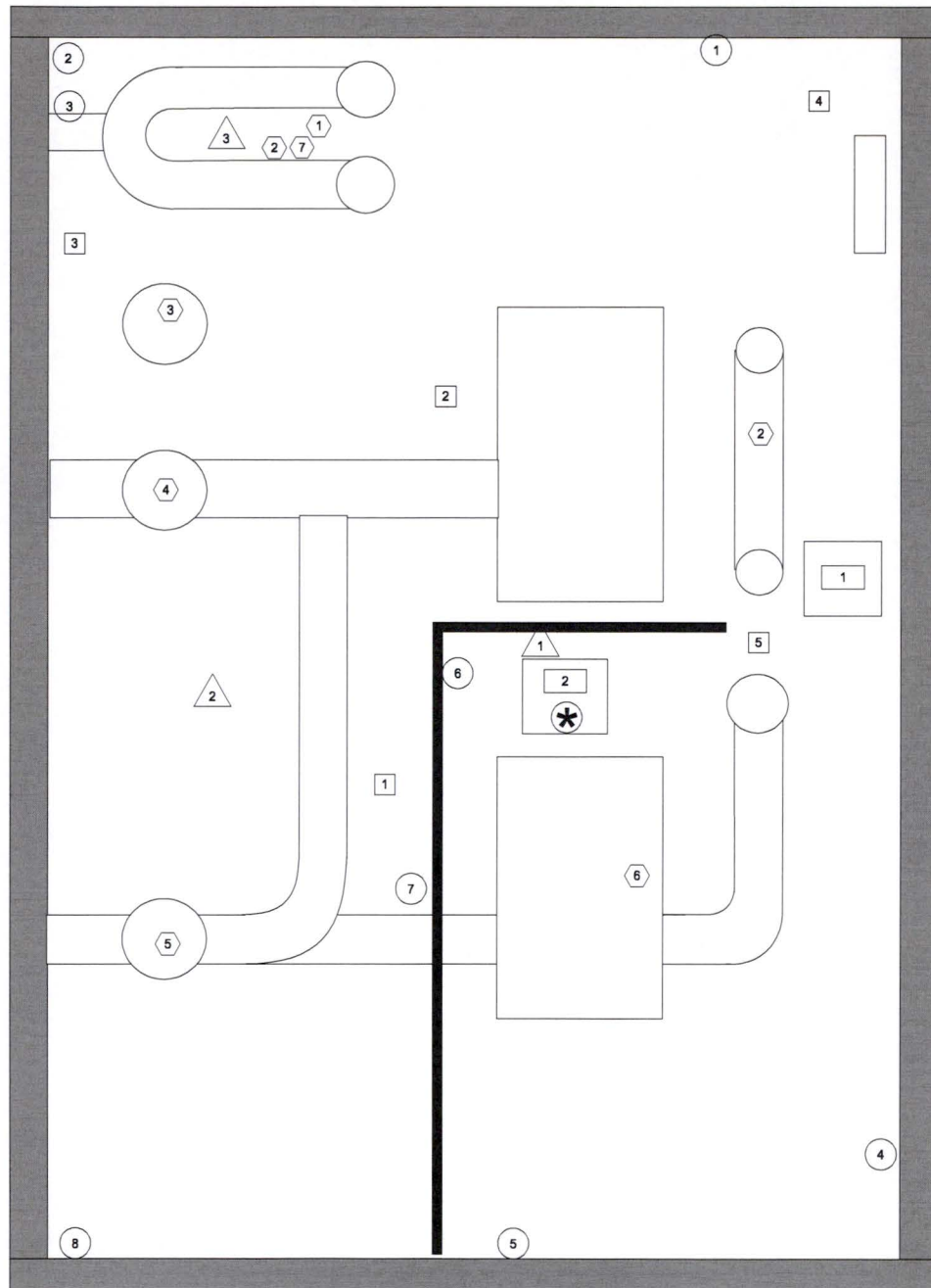
Note: 2 points also taken on shed roof, not shown 02RF1





- (XX) Walls
- (XX) Floor
- (XX) Ceiling
- (XX) Equipment
- (BK) Background
- (XFW) Cable Tunnel 03FW1

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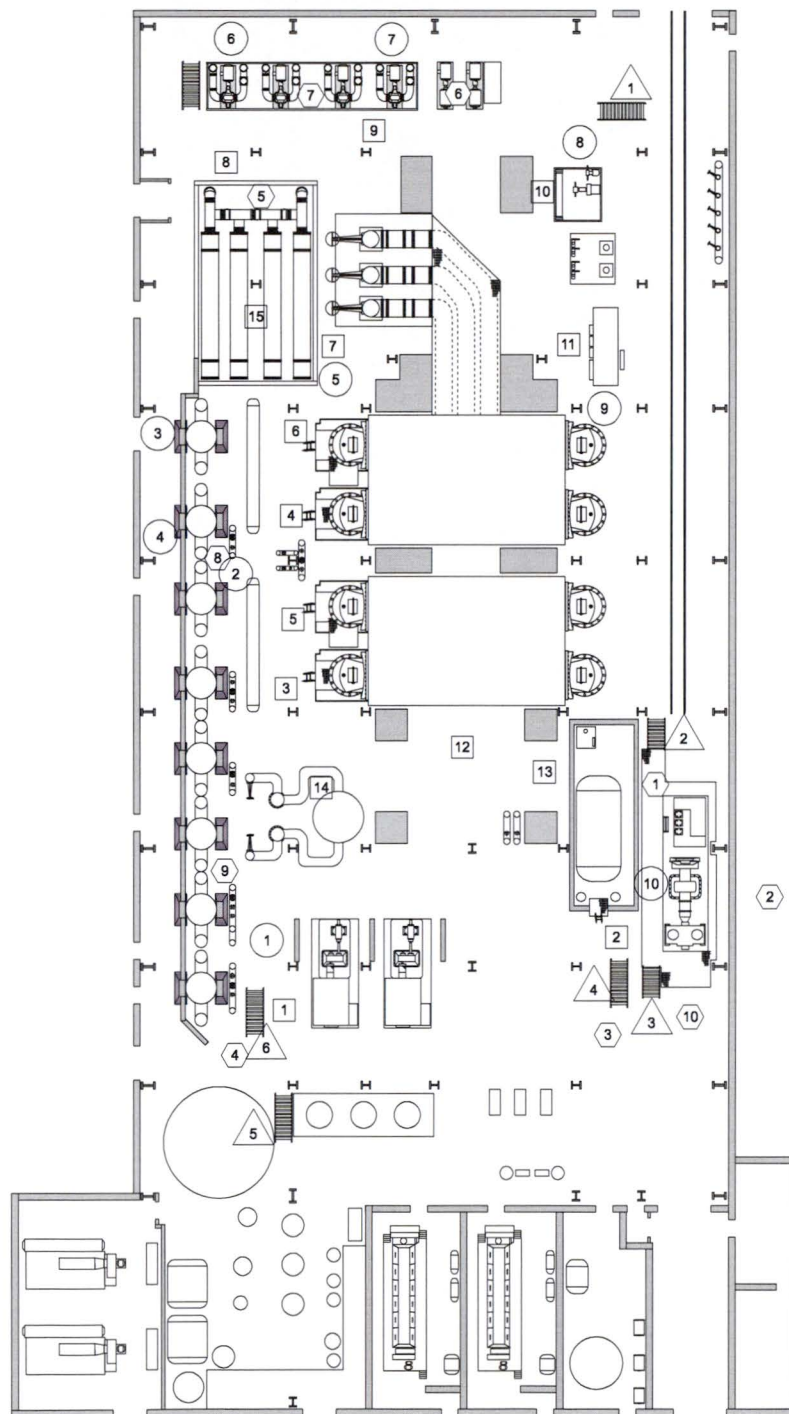
- ⊗ Walls 01WS1
- ⊠ Floor 01FL1
- △ Ceiling 01CL1
- ⊞ Equipment 01EQ1
- ⊛ Sediment Sample
- ⊞ Floor Drain 01FD1

MAINE YANKEE  
ATOMIC POWER CO.  
LICENSE  
TERMINATION PLAN

Site Characterization Fire Pump House  
Survey Package B0400

Figure  
2-70



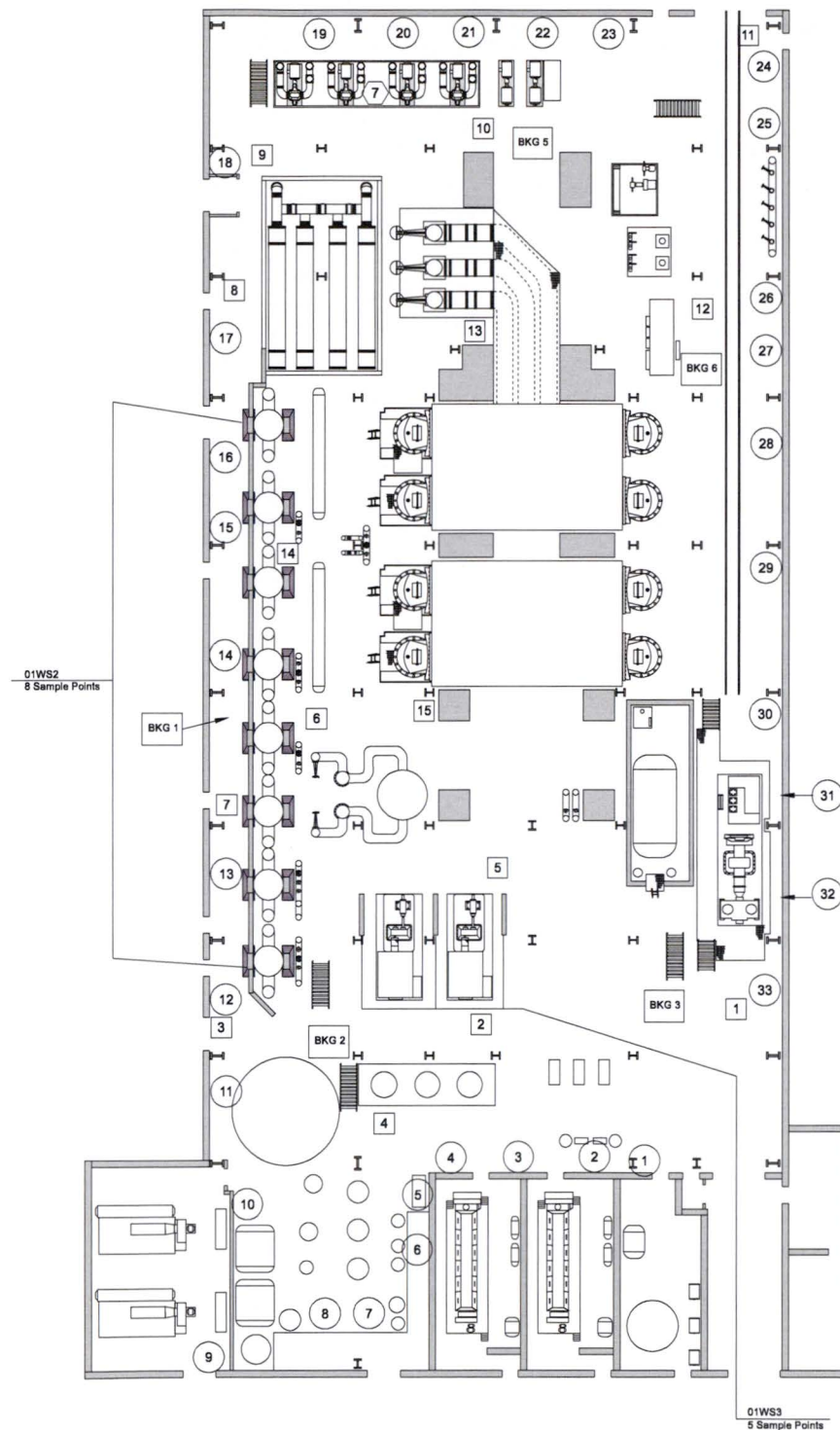


- ⊗ Cable Trays 01CL1
- ⊗ Ceiling 01EQ1
- △ Stairways 01WS1, 01WS2, ... 01WS6
- ⊗ Horizontal Supports 01CL2

MAINE YANKEE  
ATOMIC POWER CO.  
LICENSE  
TERMINATION PLAN

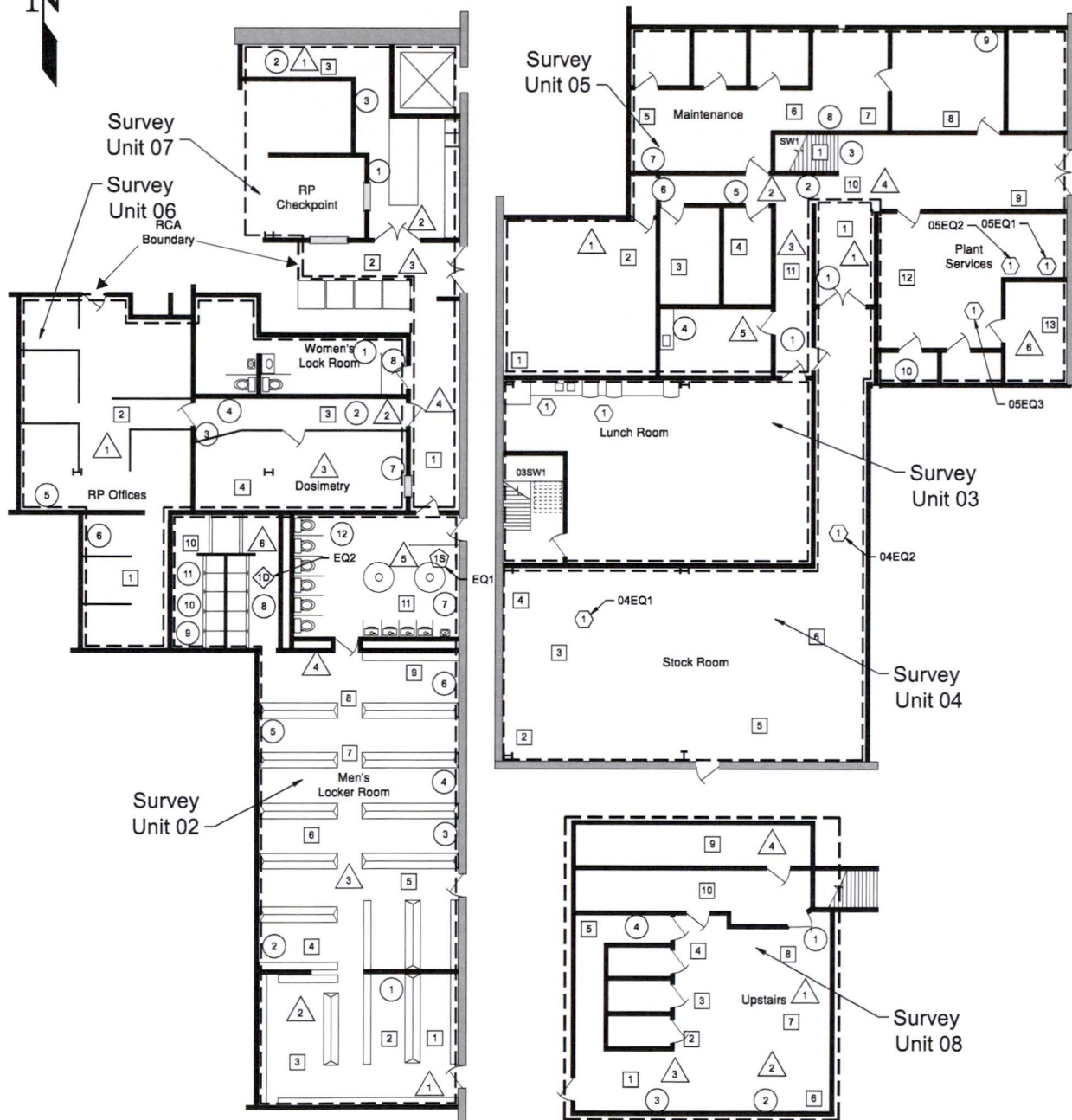
Site Characterization Turbine Building 21 ft  
Survey Package B0500

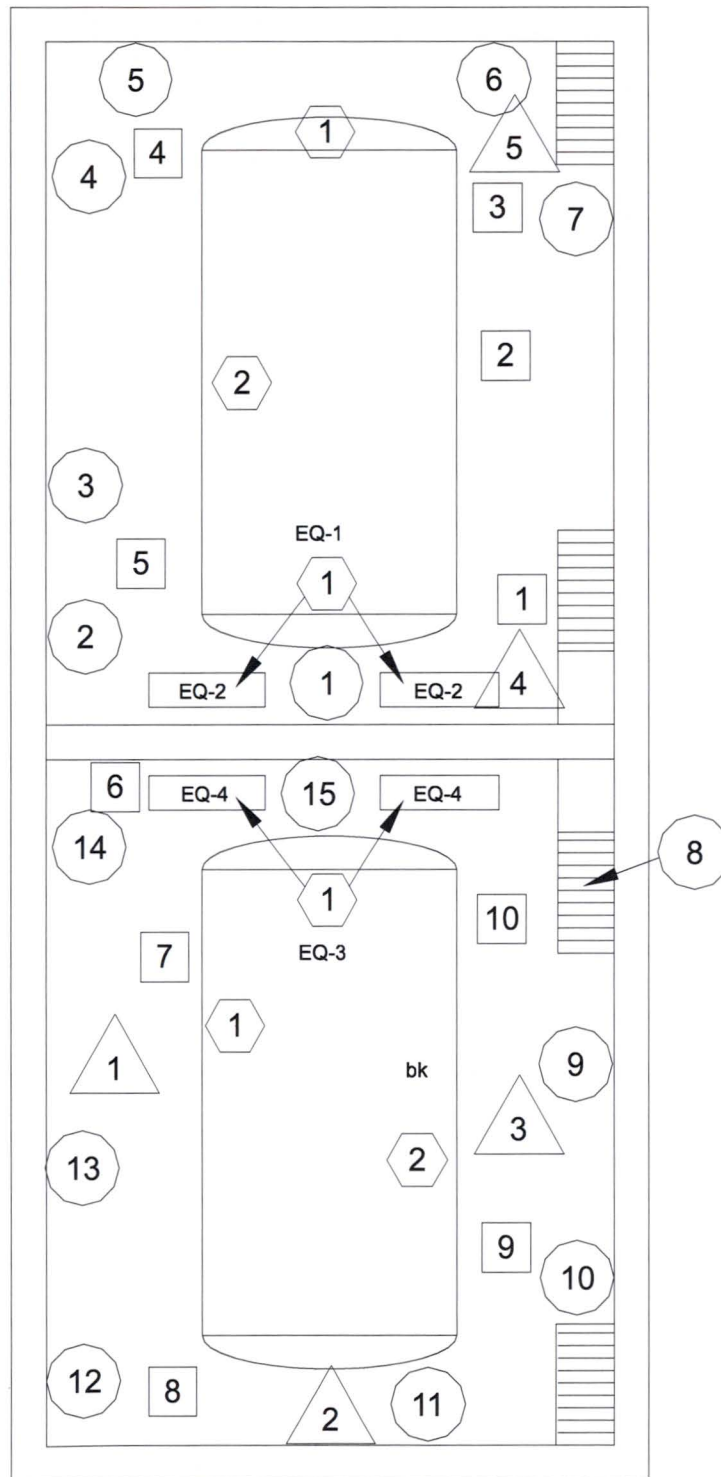
Figure  
2-71



XX Walls  
XX Floor

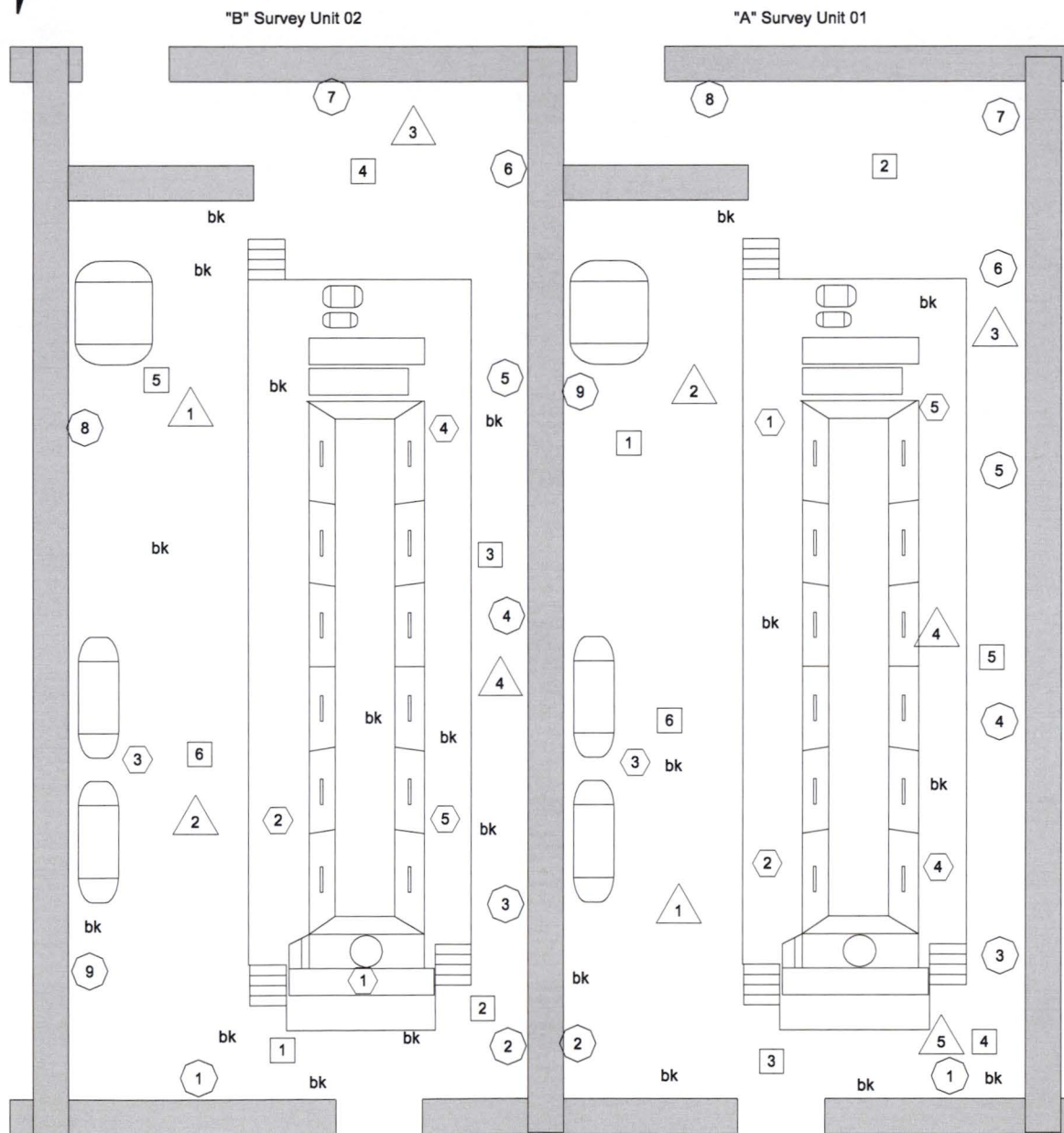


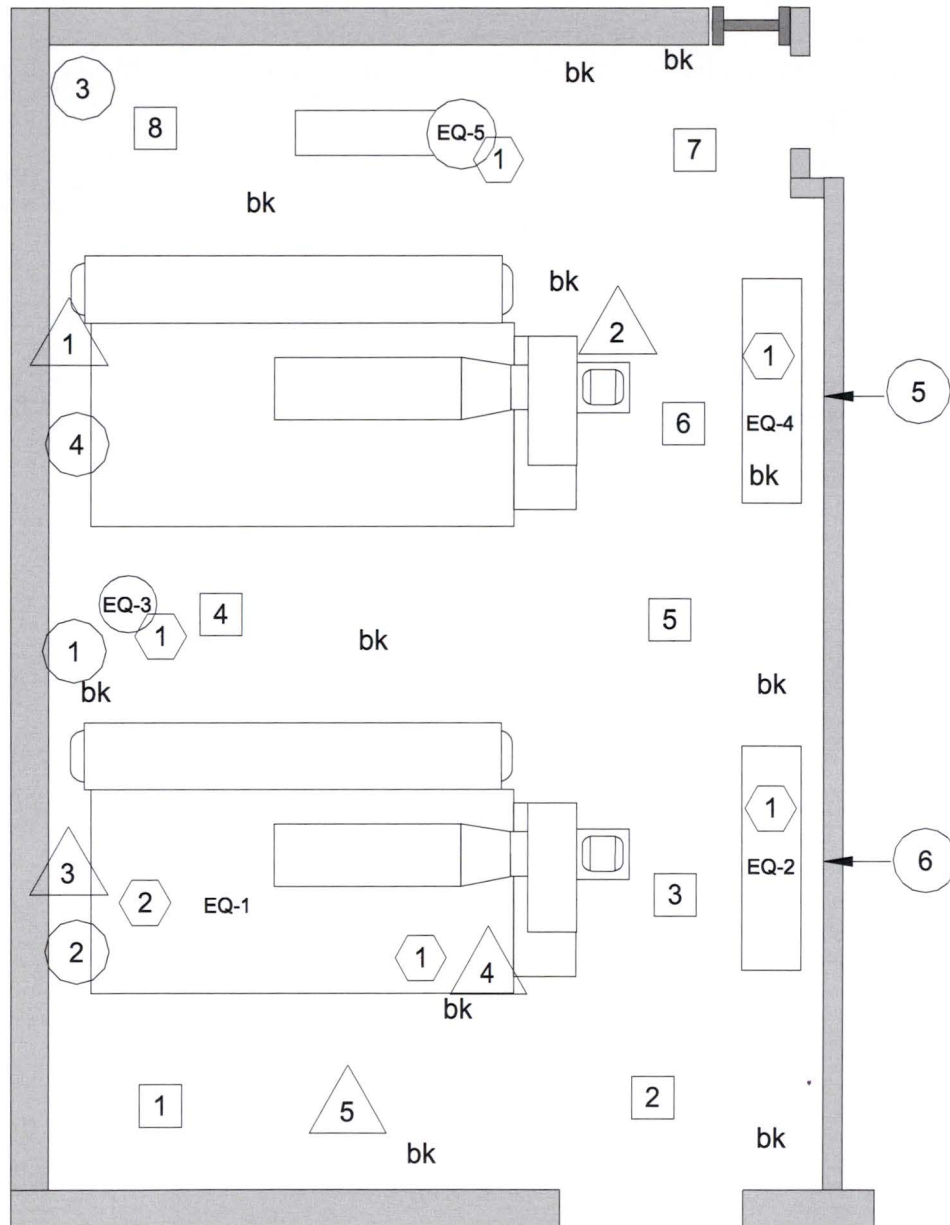








- Walls
- Floor
- Ceiling
- Equipment
- bk Background

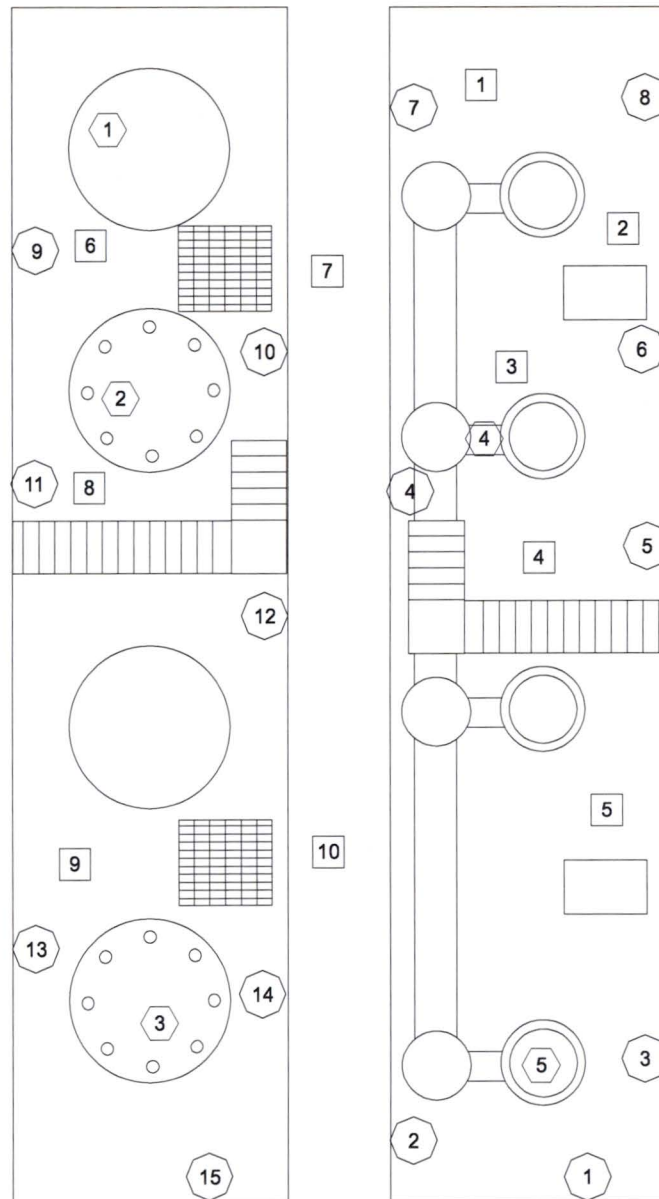
Survey Unit 01





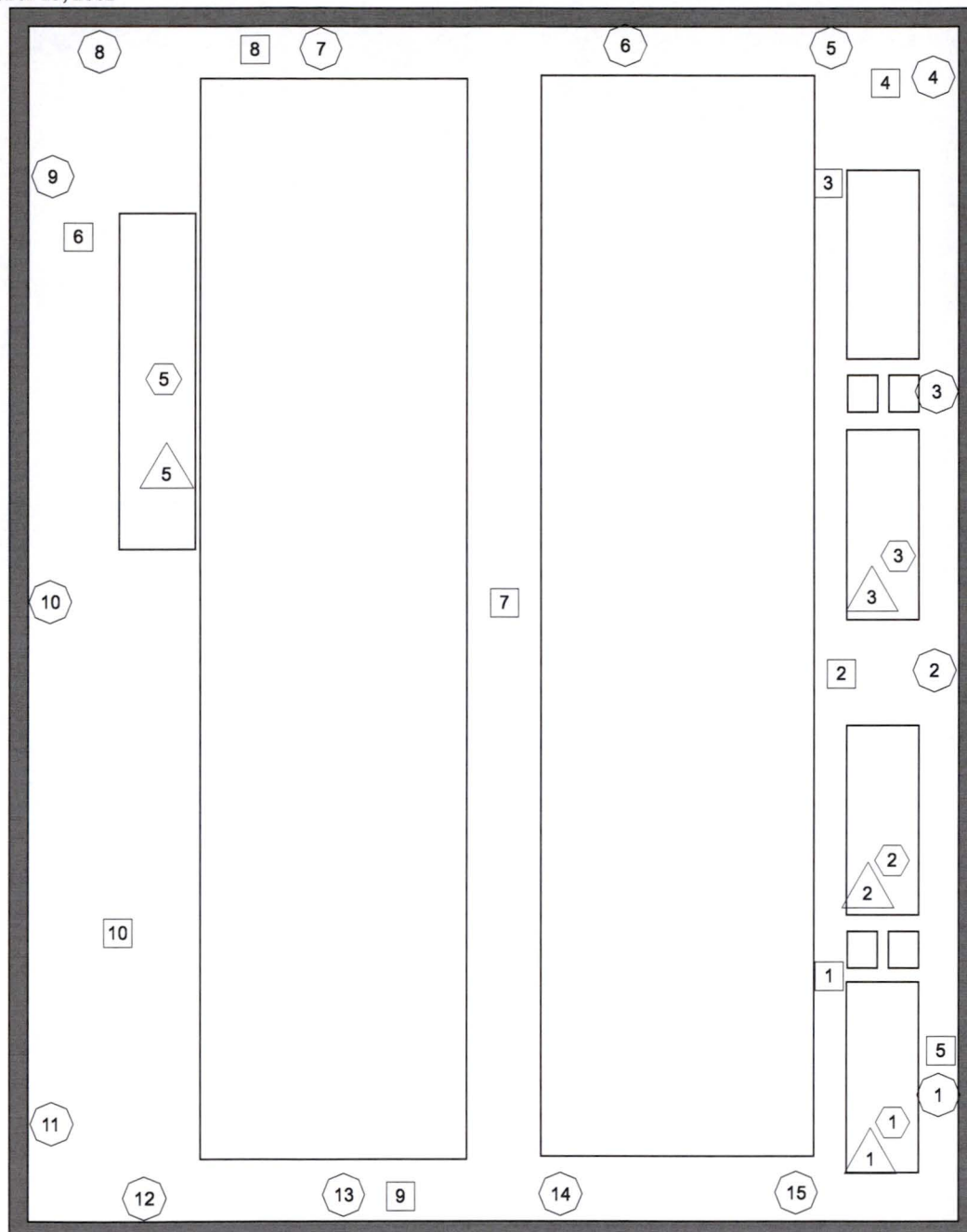
-  Walls
-  Floor
-  Ceiling
-  Equipment
- bk Background





- XX Walls
- XX Floor
- XX Equipment

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- Walls 02WS1
- Floor 02FL1
- Equipment 02EQ1
- Ceiling 02CL1

MAINE YANKEE  
ATOMIC POWER CO.  
LICENSE  
TERMINATION PLAN

Site Characterization Recirc Water Pump House  
Upper Elevation Survey Package B1100

Figure  
2-78

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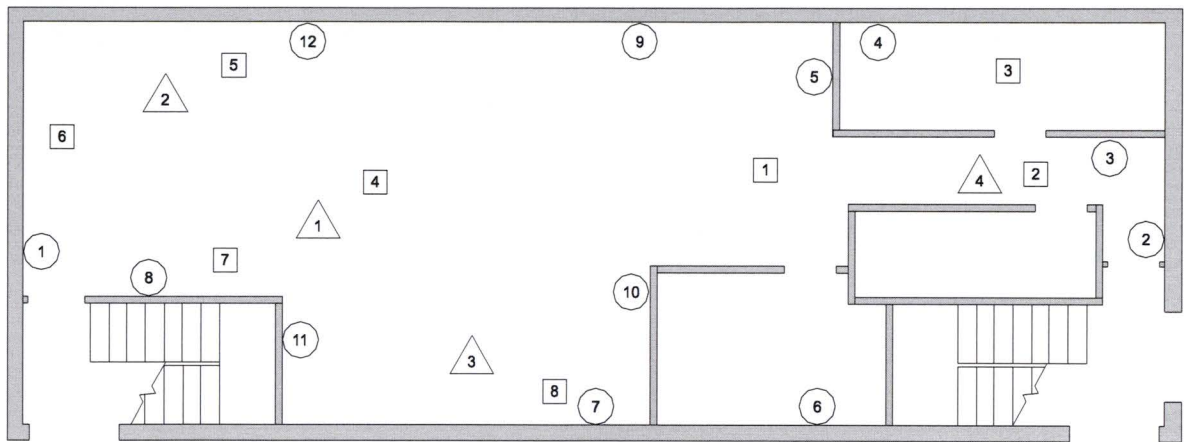
- Walls 01WS1
- Floor 01FL1
- Equipment 01EQ1, Q2, Q3
- Ceiling 01CL1
- bk Background

MAINE YANKEE  
ATOMIC POWER CO.  
LICENSE  
TERMINATION PLAN

Site Characterization Administration Building  
Front office Survey Package B1100

Figure  
2-79

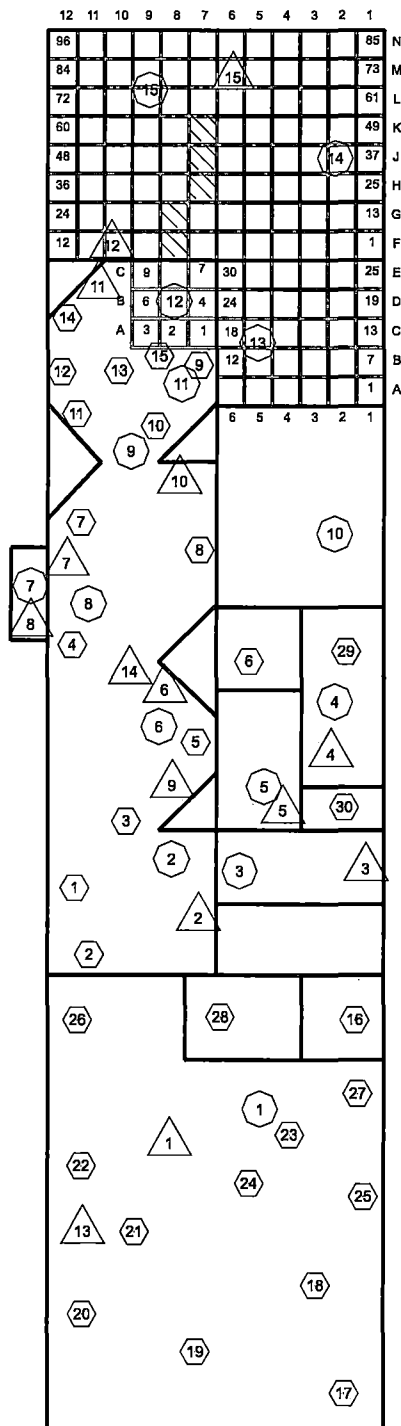




First Floor / I & C Shop

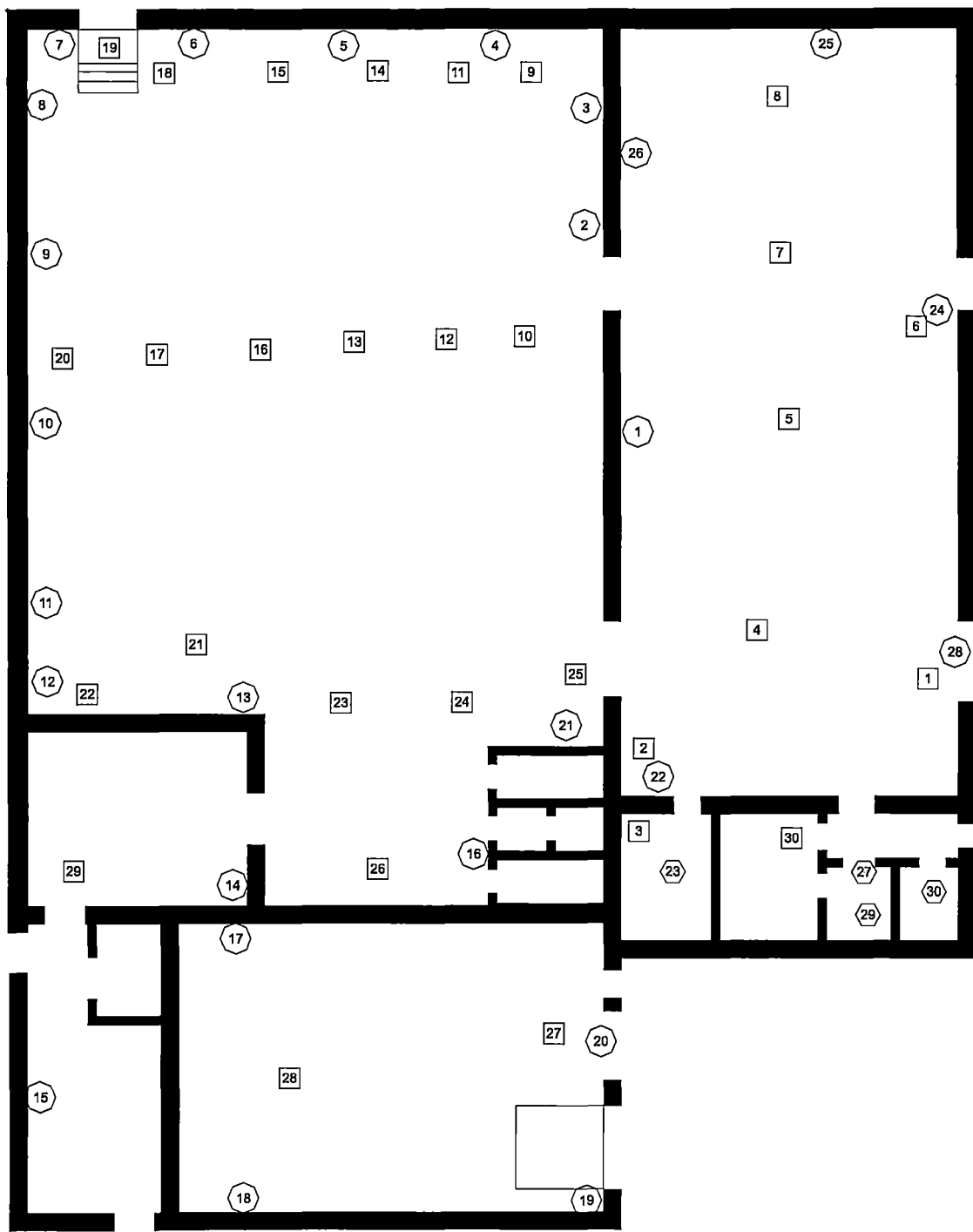
- (XX) Walls 01WS1, 02WS1, 03WS1
- (XX) Floor 01FL1, 02FL1, 03FL1
- (XX) Equipment
- (XX) Ceiling 01CL1, 02CL1, 03CL1

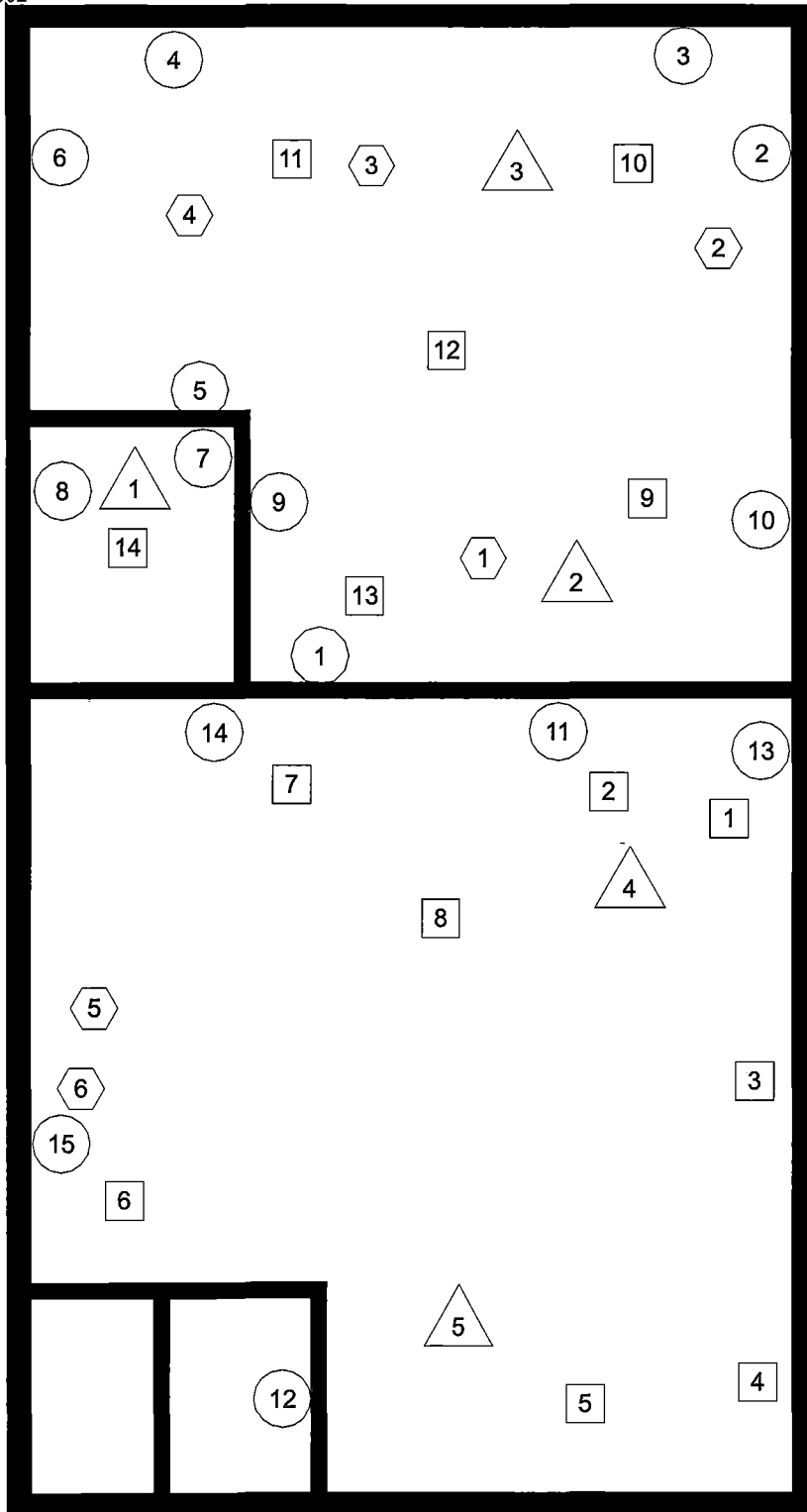
MYAPC License Termination Plan  
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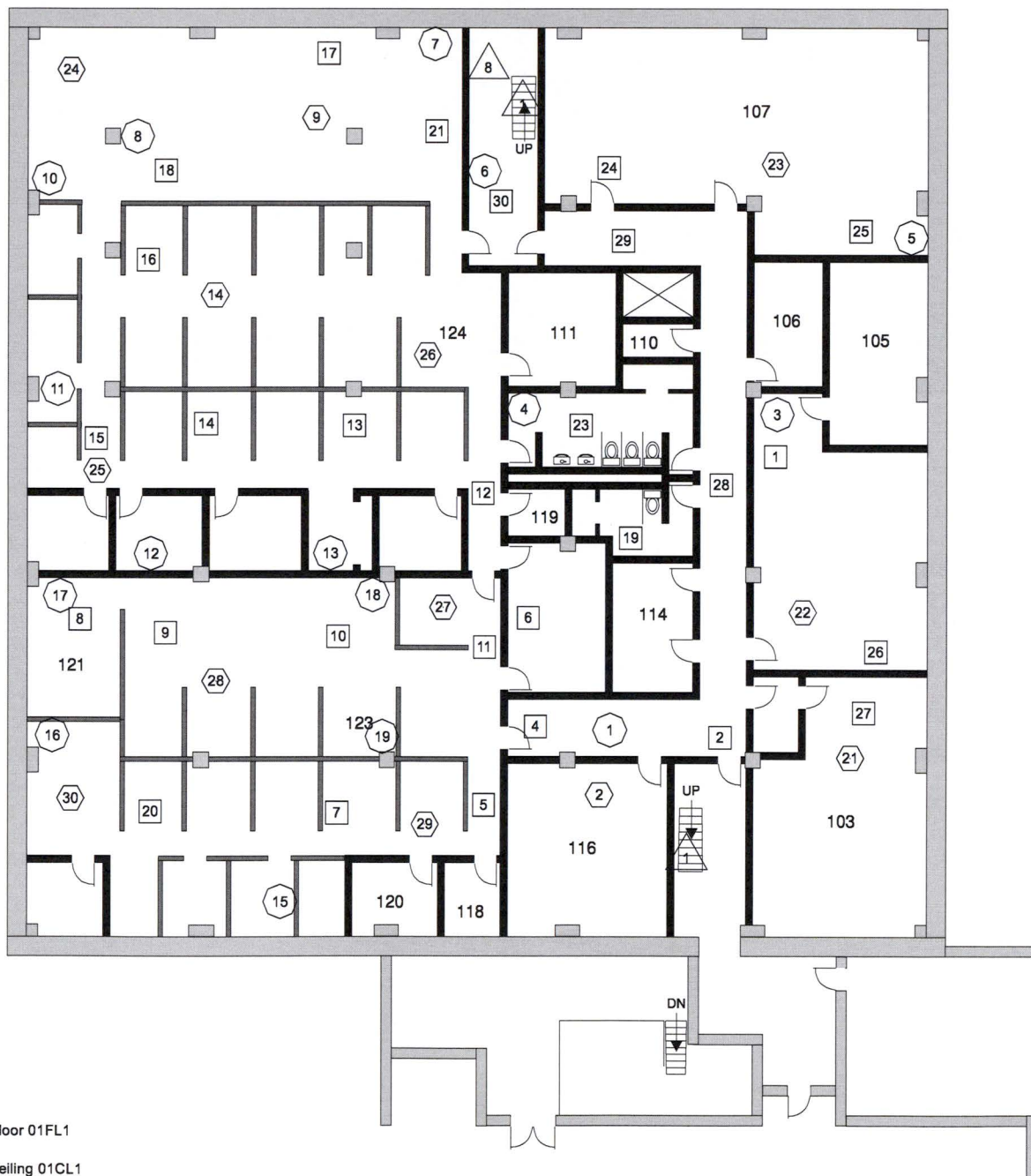
- Walls 01WS1, 02WS1, 03WS1
- Floor 01FL1, 02FL1, 03FL1
- Equipment
- Ceiling 01CL1, 02CL1, 03CL1
- Area Where Carpet Removed

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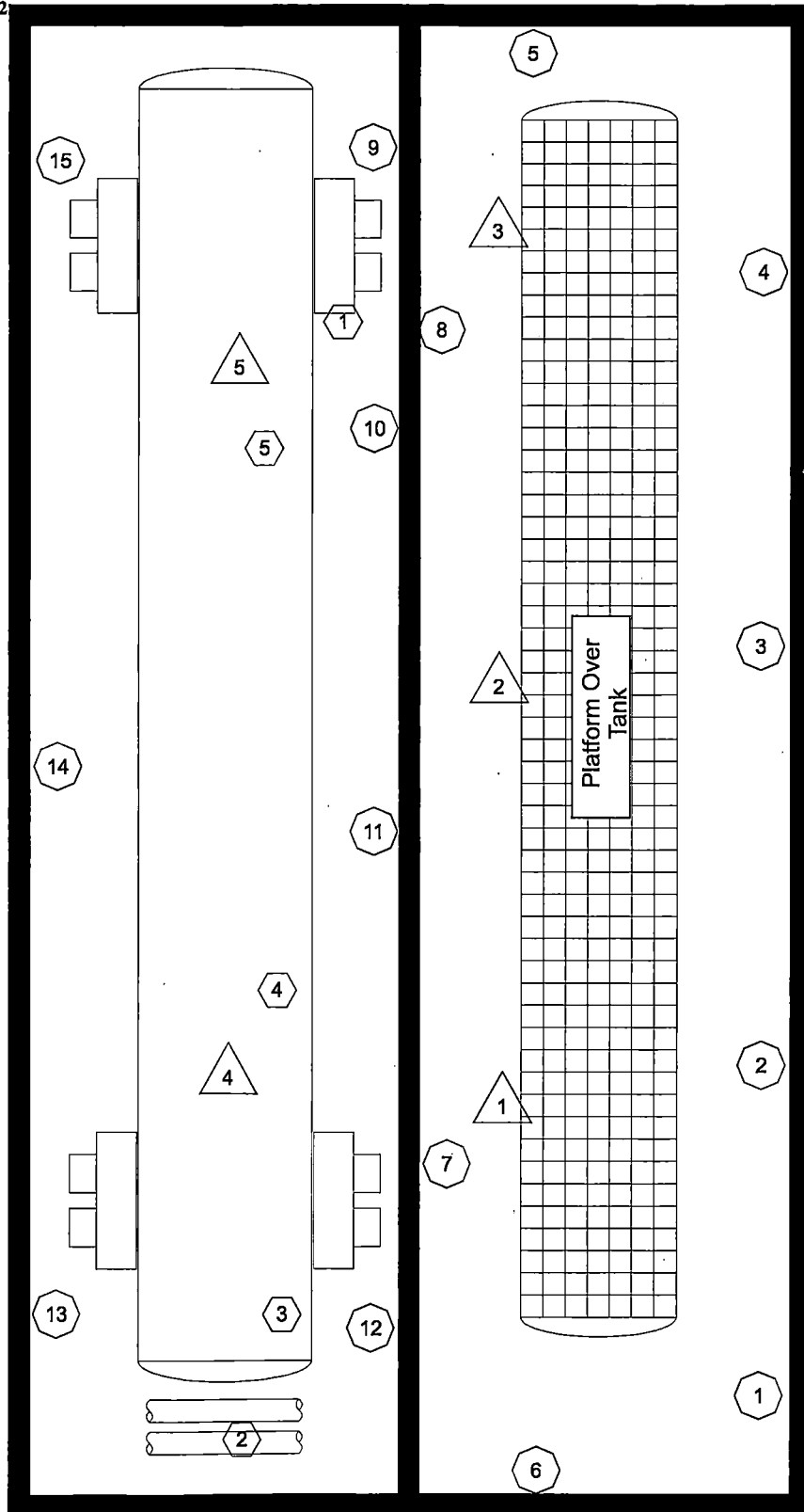




- XX Floor 01FL1
- XX Equipment 01EQ1
- XX Walls 01WS1
- XX Ceiling 01CL1

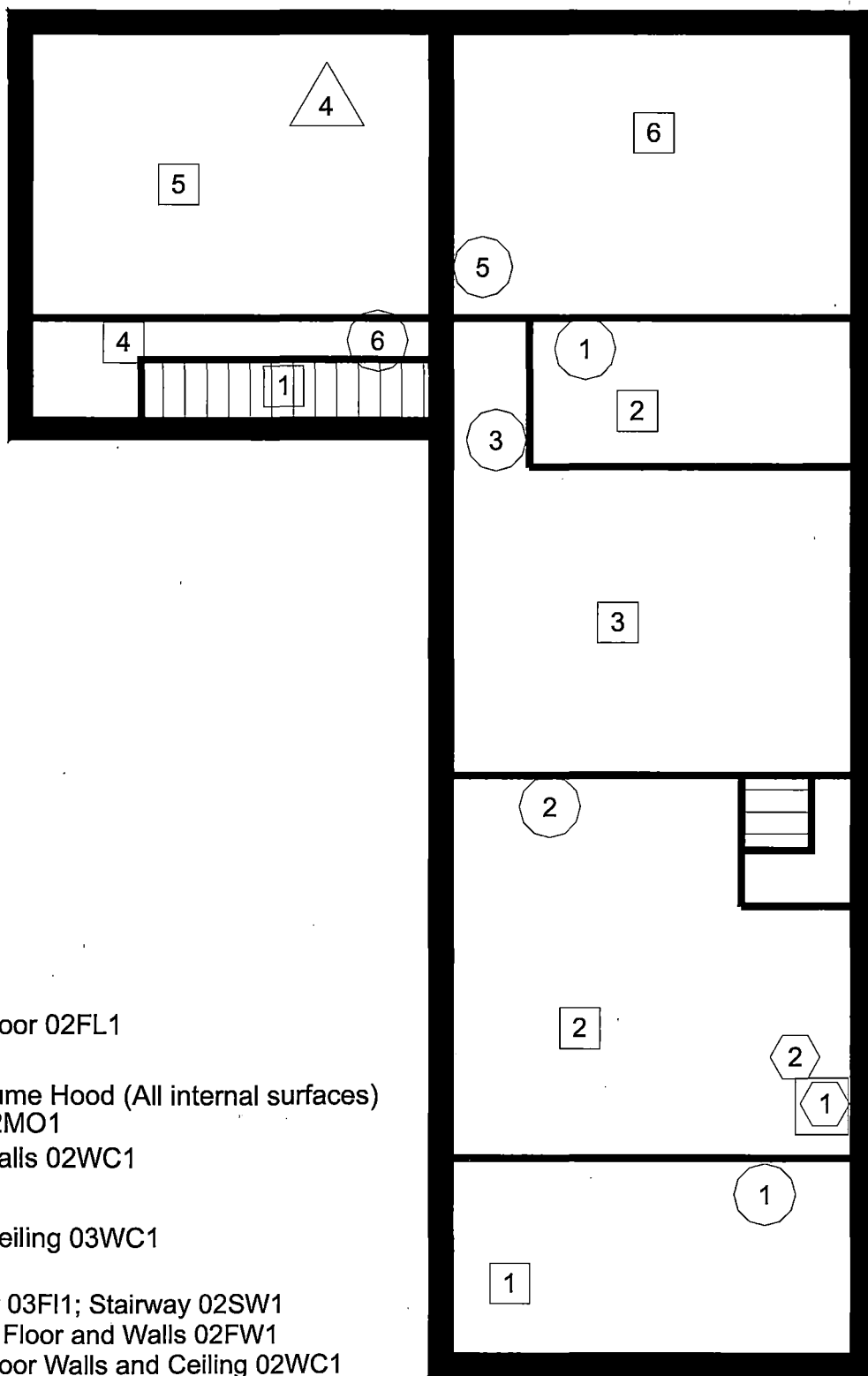


- XX Floor 01FL1
- XX Ceiling 01CL1
- XX Walls 01WS1
- XX Stairwell 01SW1



- Equipment
- Walls
- Ceiling

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Floor 02FL1



Fume Hood (All internal surfaces)  
02MO1



Walls 02WC1



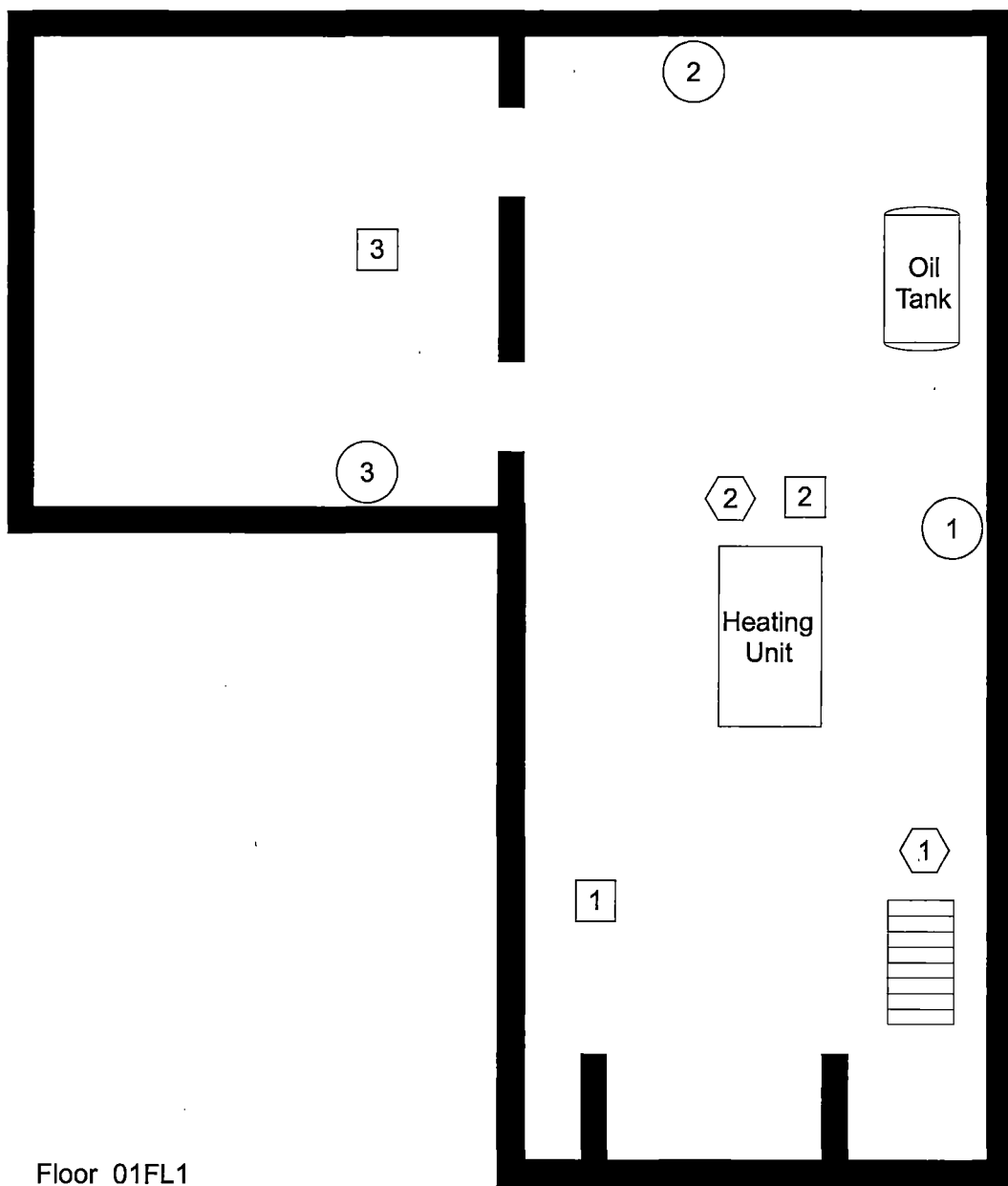
Ceiling 03WC1

Attic Floor 03FI1; Stairway 02SW1

Bathroom Floor and Walls 02FW1

Ground Floor Walls and Ceiling 02WC1





Floor 01FL1



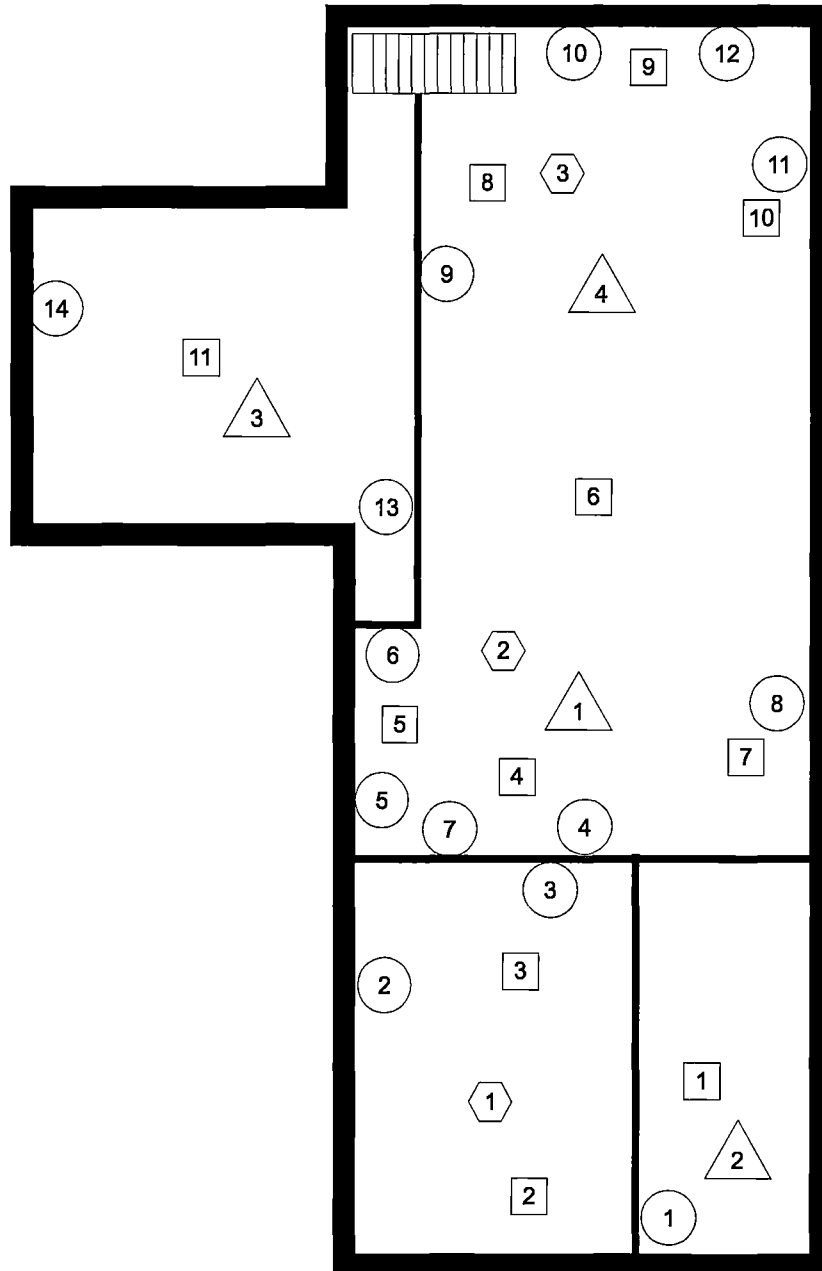
Soil Sample







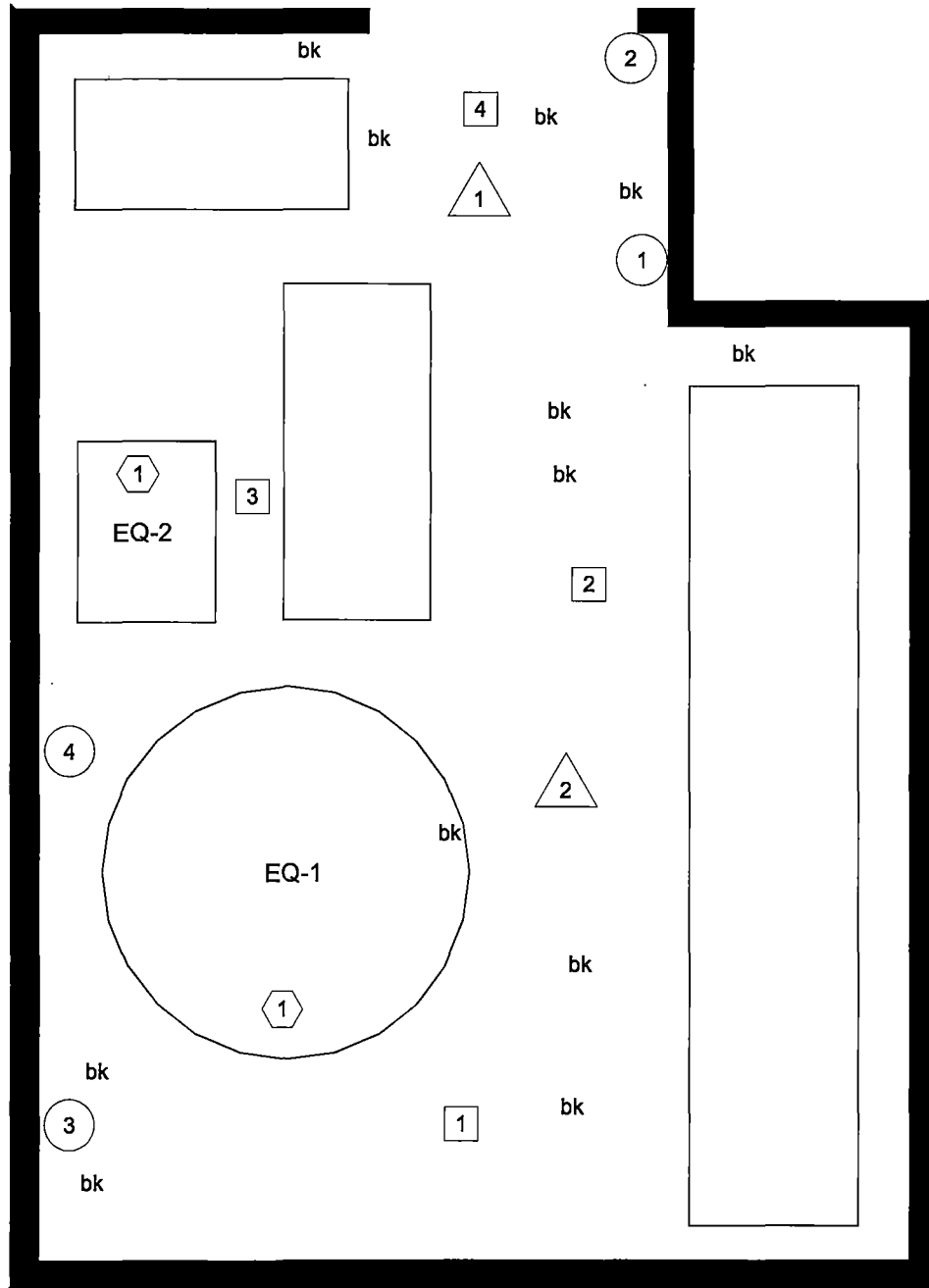
Walls 01WC1



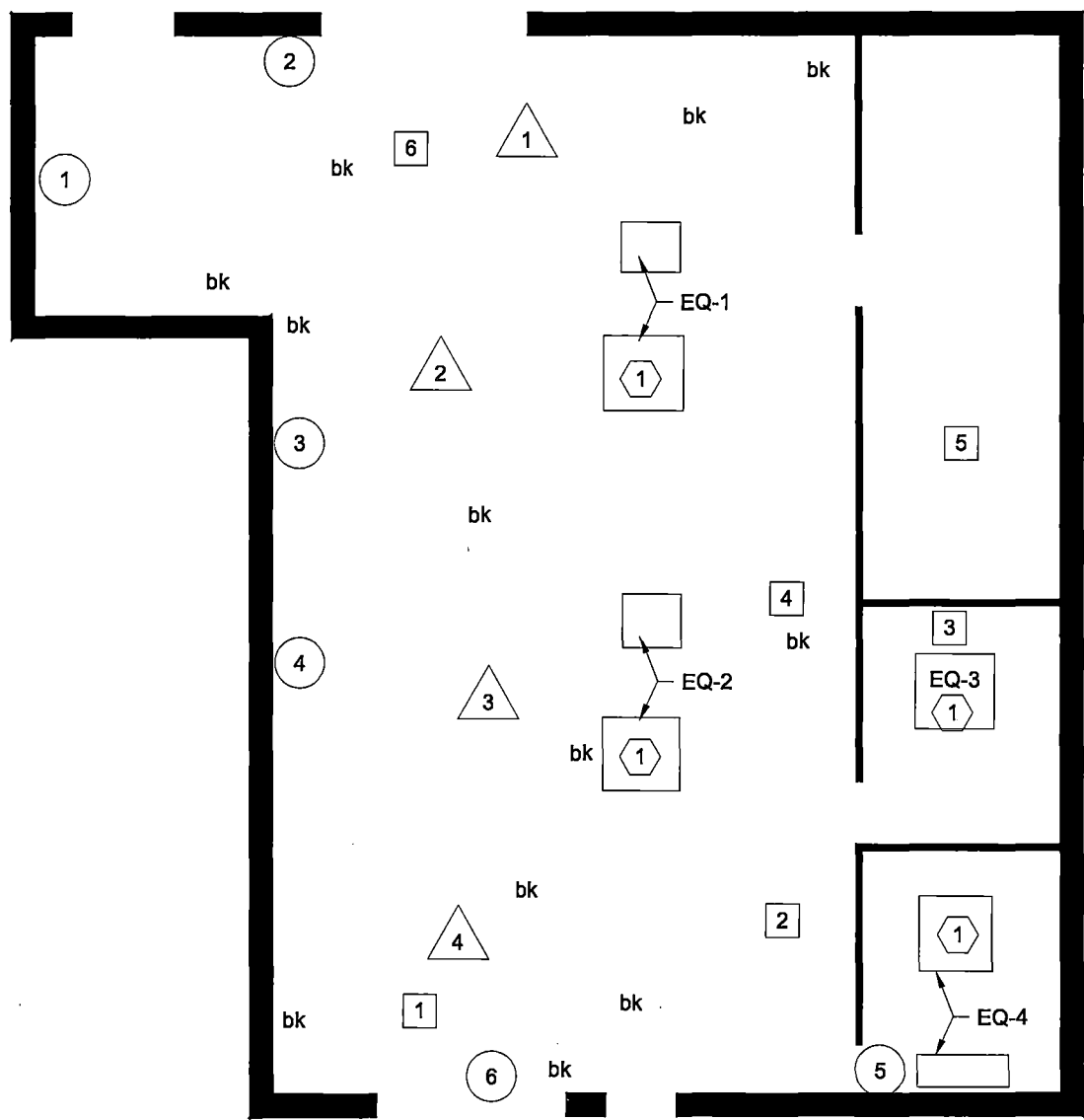
01FL1







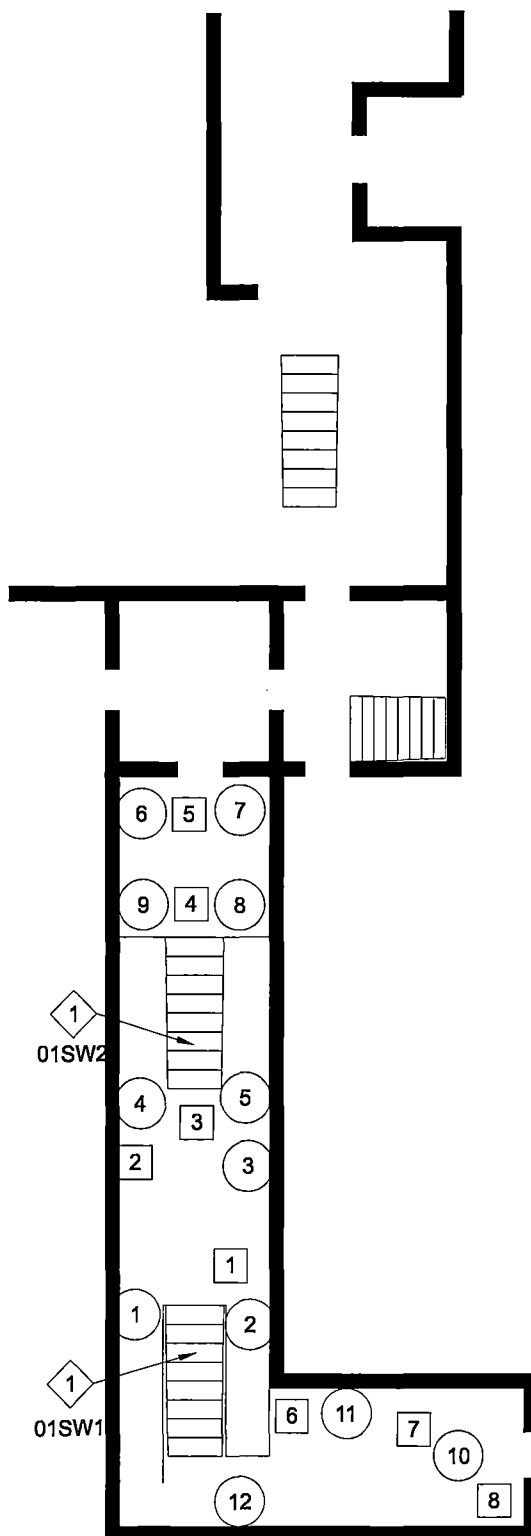
-  Floor
-  Background
-  Walls
-  Ceiling



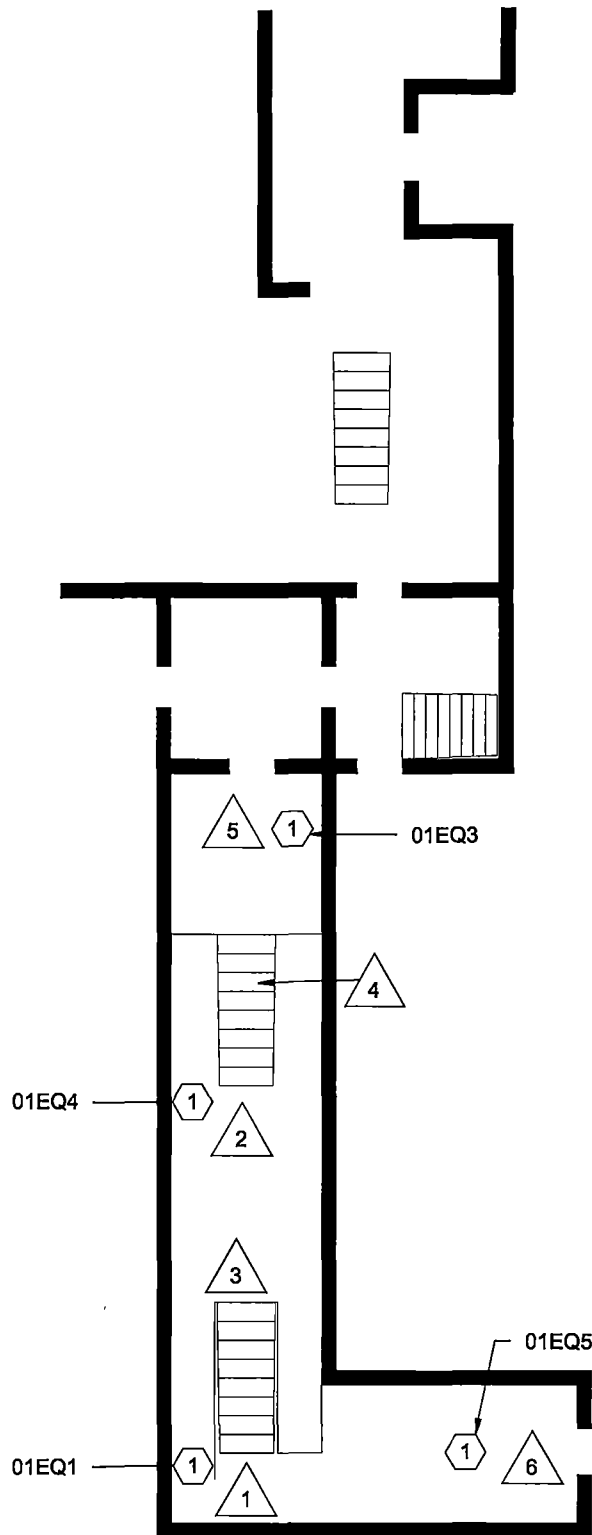
- Ceiling
- Floor
- Equipment
- Walls
- bk Background



-  Ceiling
-  Floor
-  Equipment
-  Walls
- bk Background



- XX Floor 01FL1
- XX Walls 01WS1
- XX Stairwell

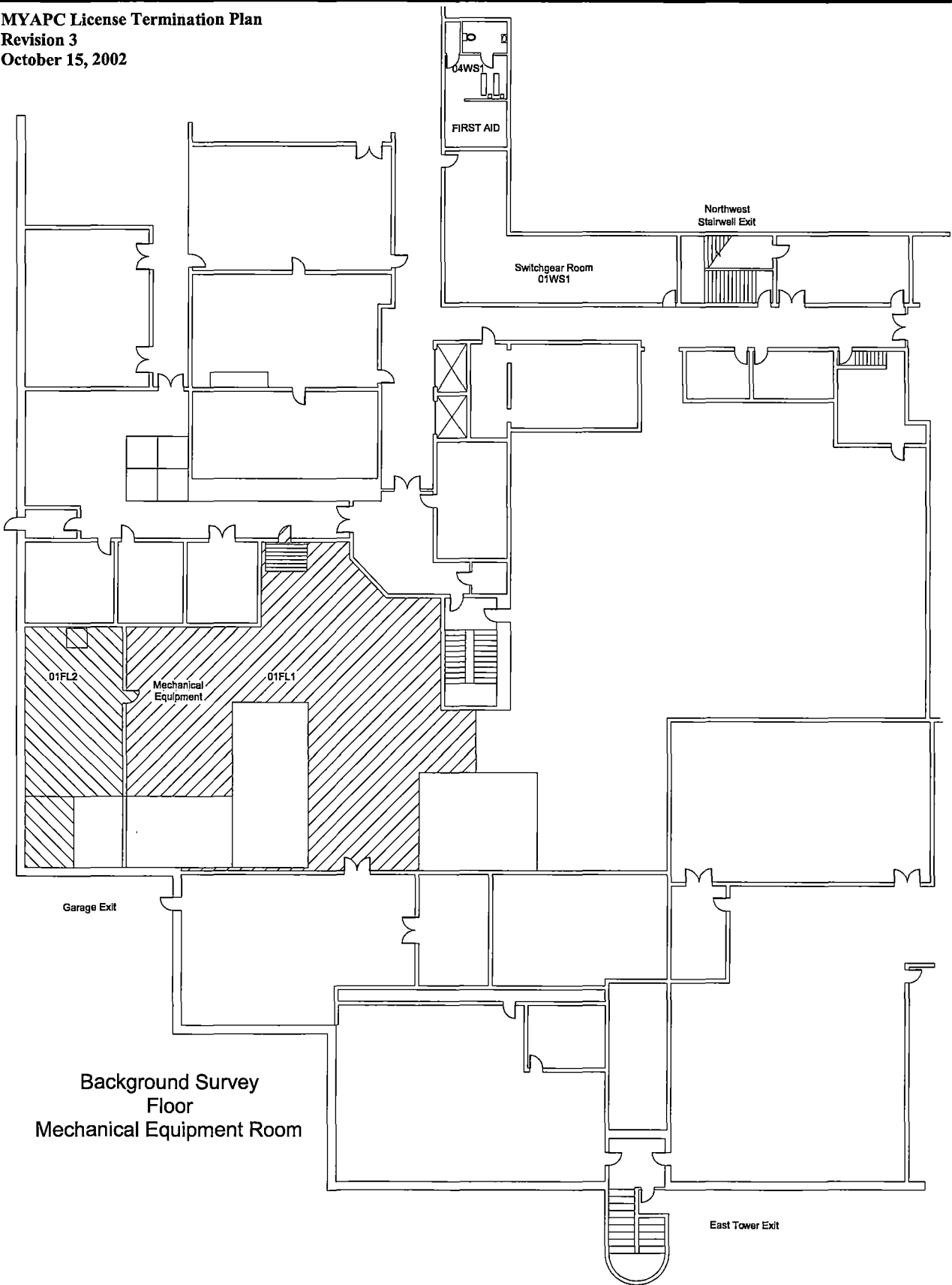


Ceiling

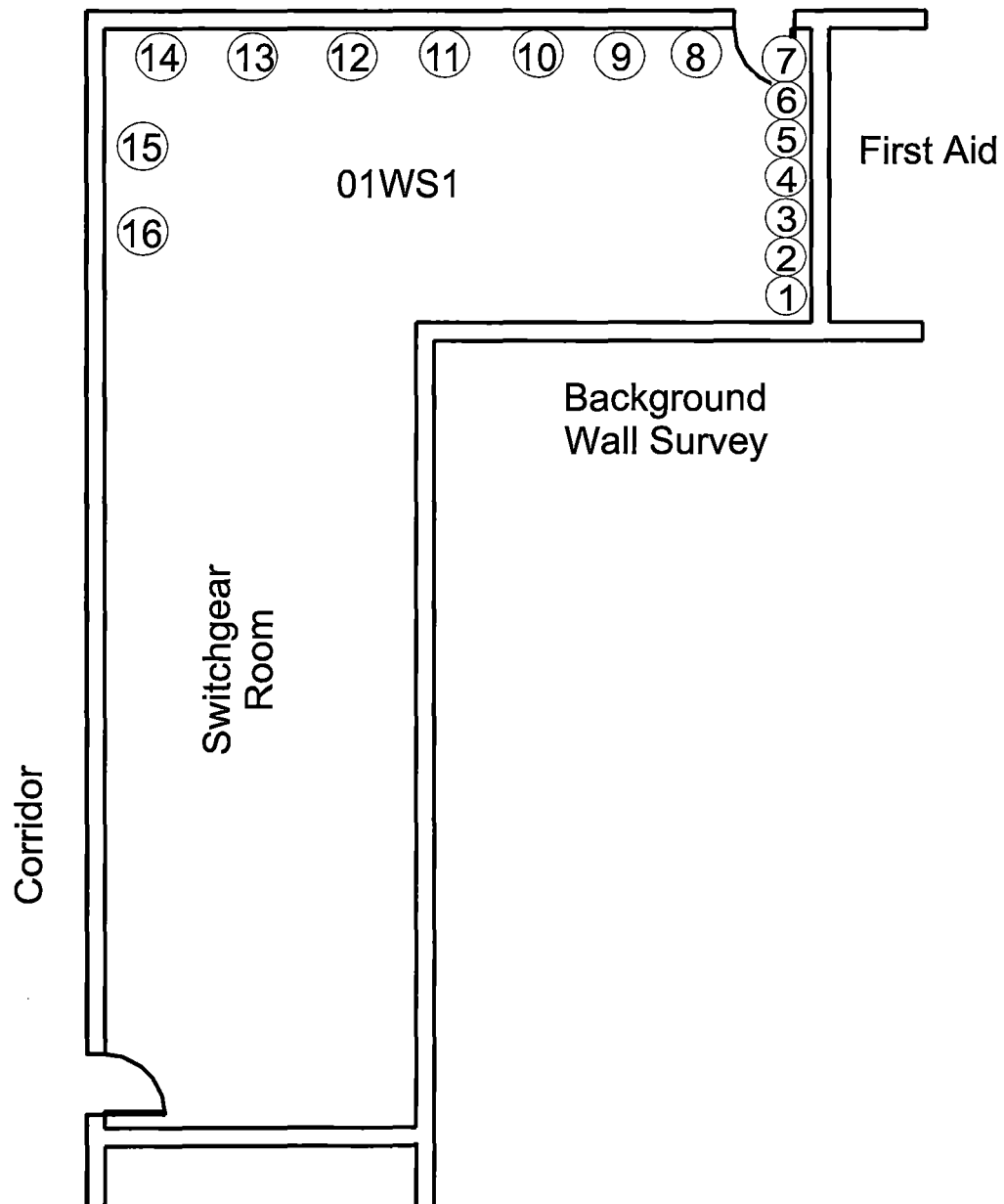


Equipment

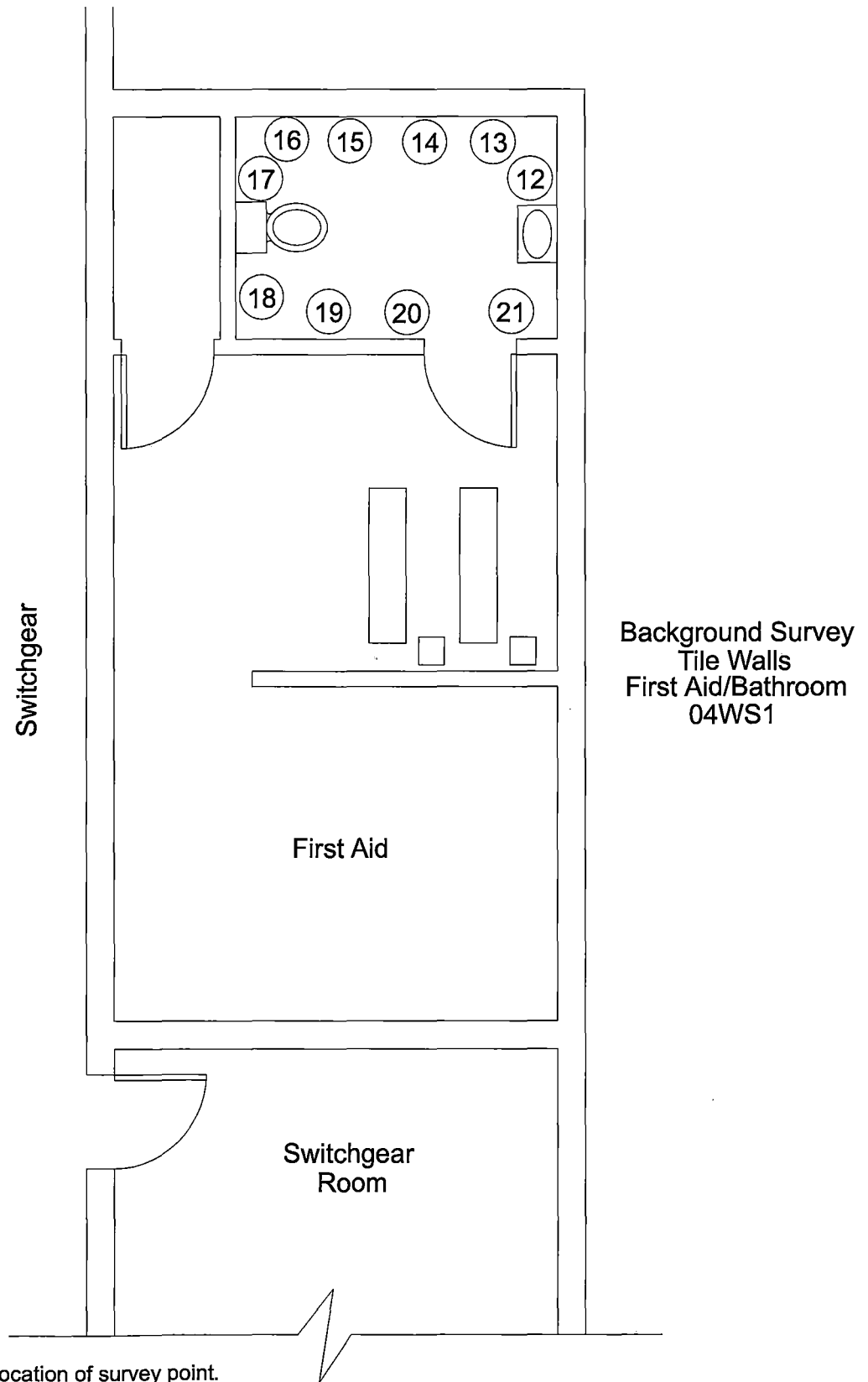
**MYAPC License Termination Plan**  
**Revision 3**  
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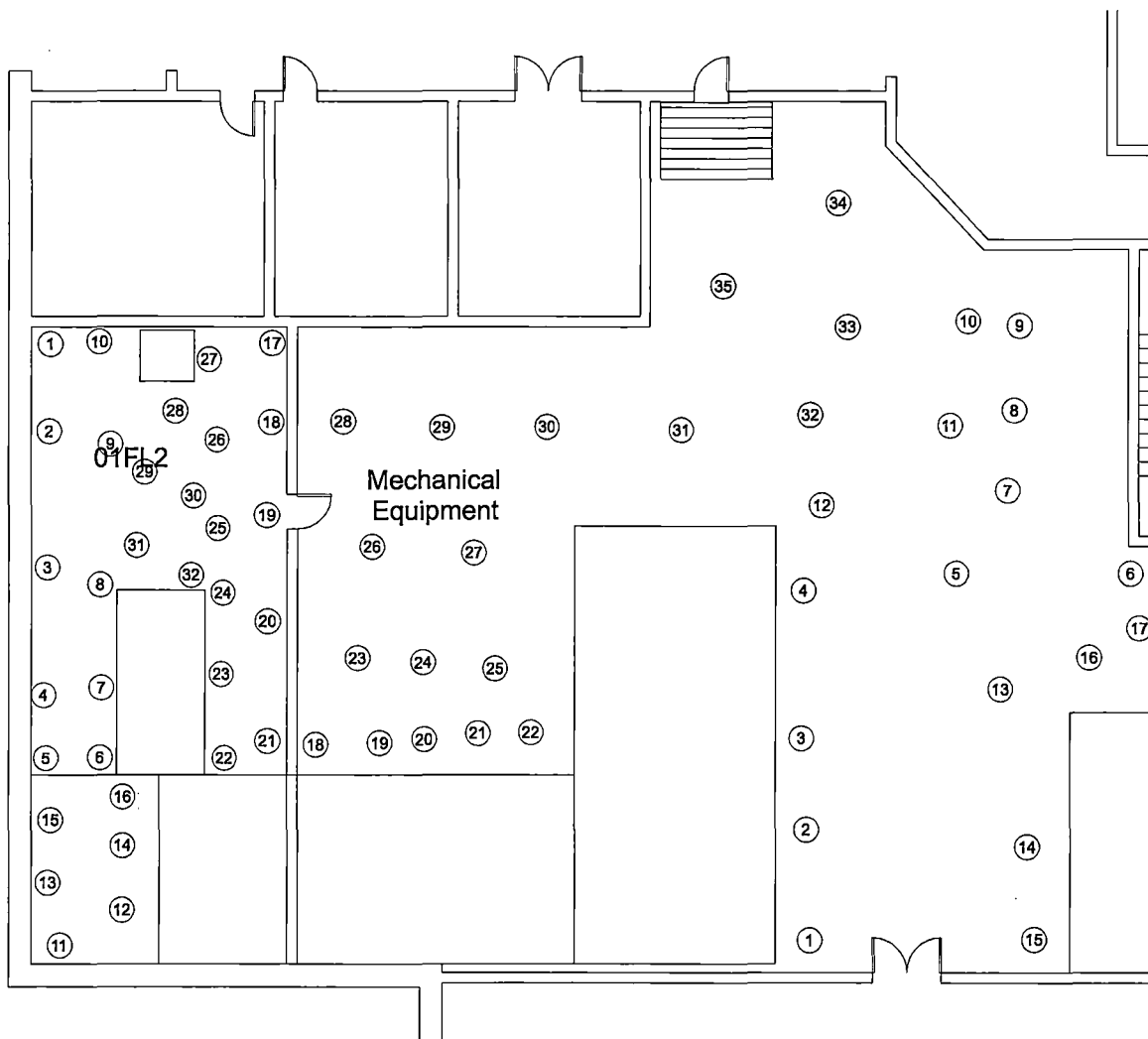






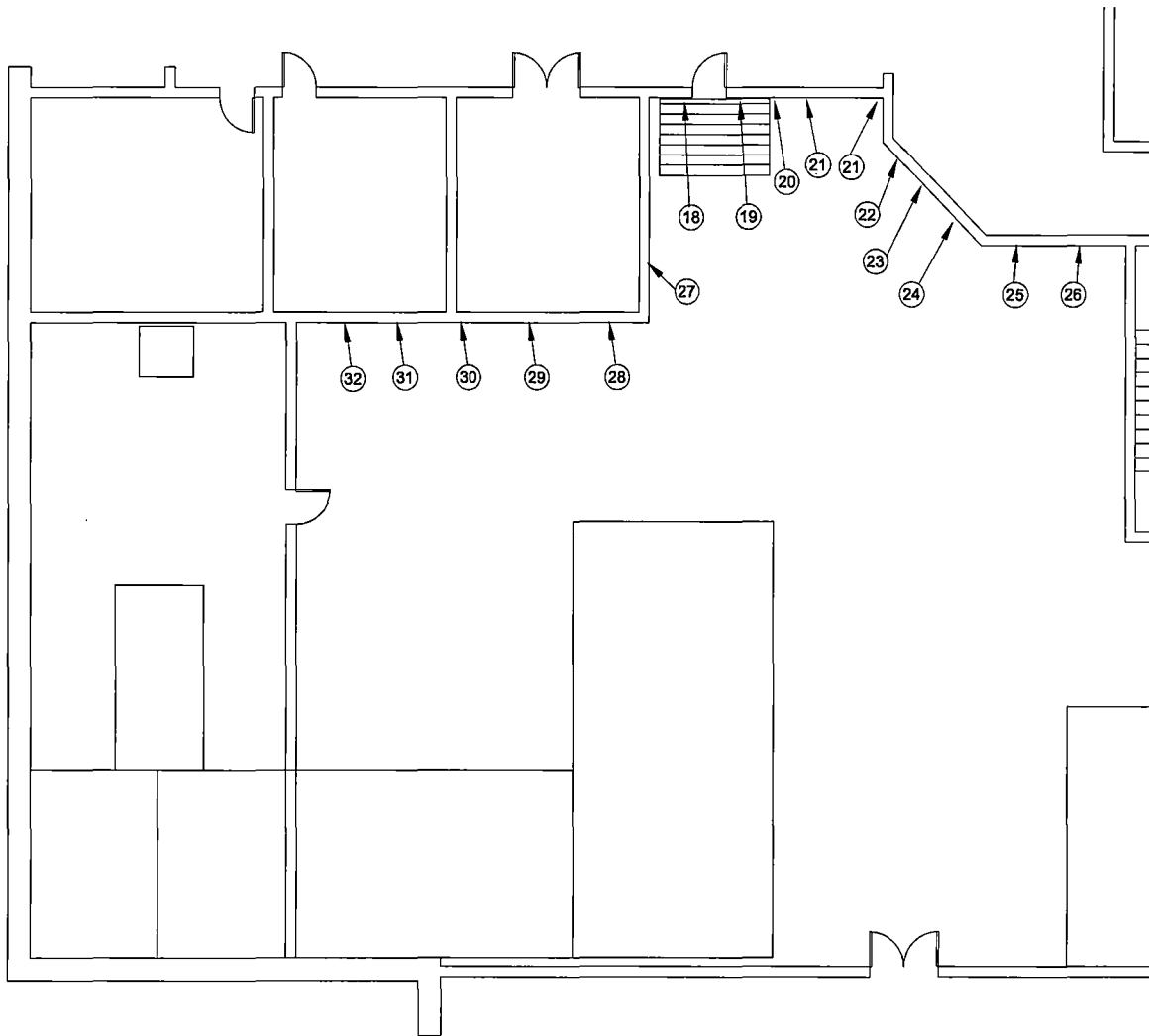
⊗ Approximate location of survey point.





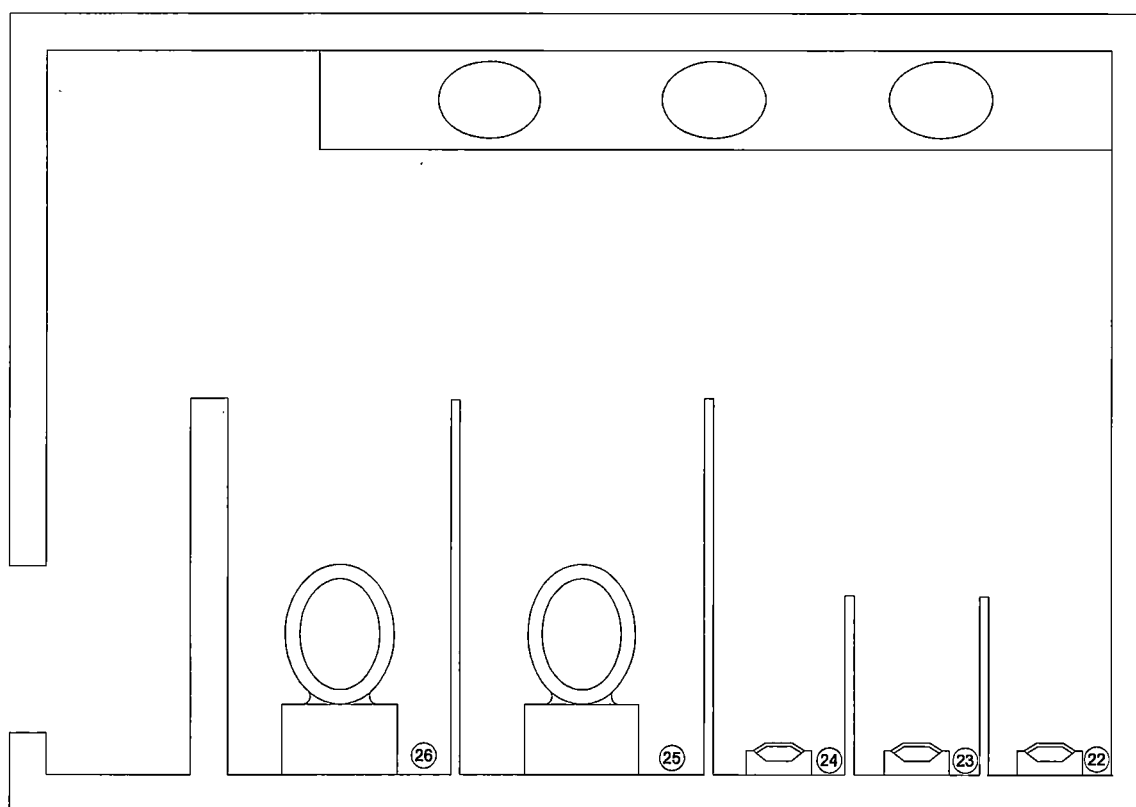
Floor- Garage Exit  
Background Survey

⊗ Approximate location of survey point.



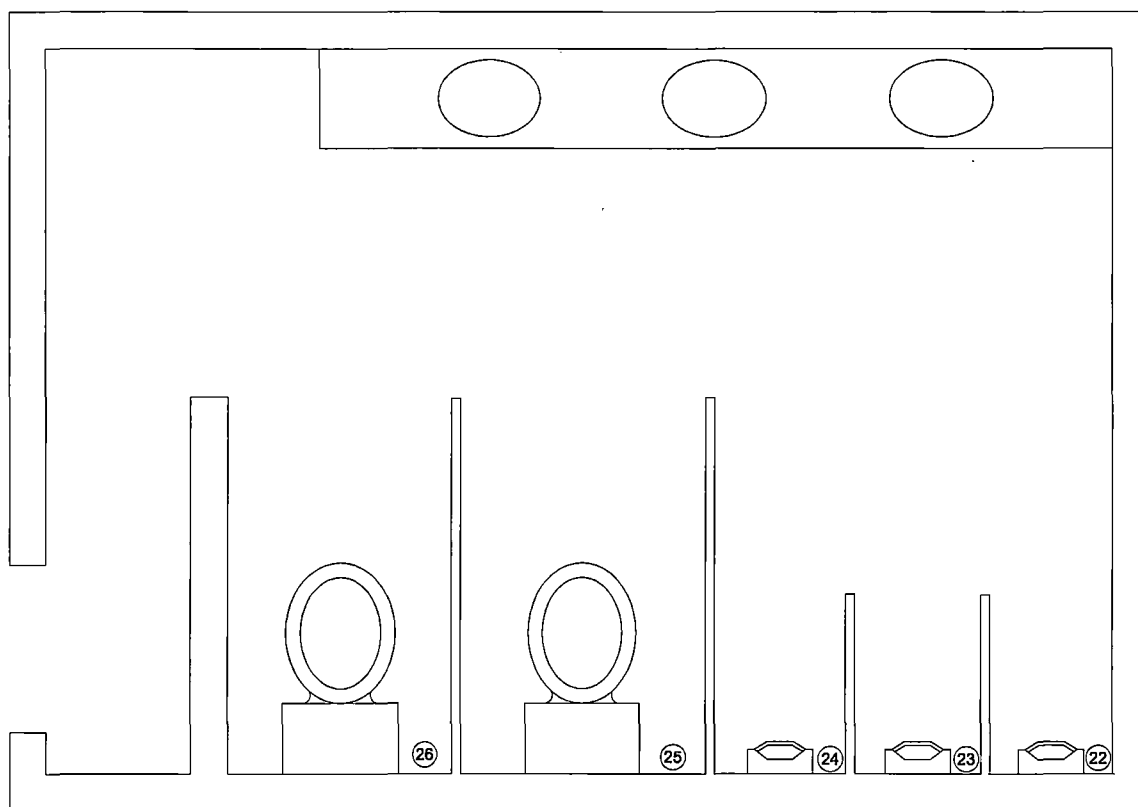
Mechanical Equipment Room  
Background Survey

⊗ Approximate location of survey point.



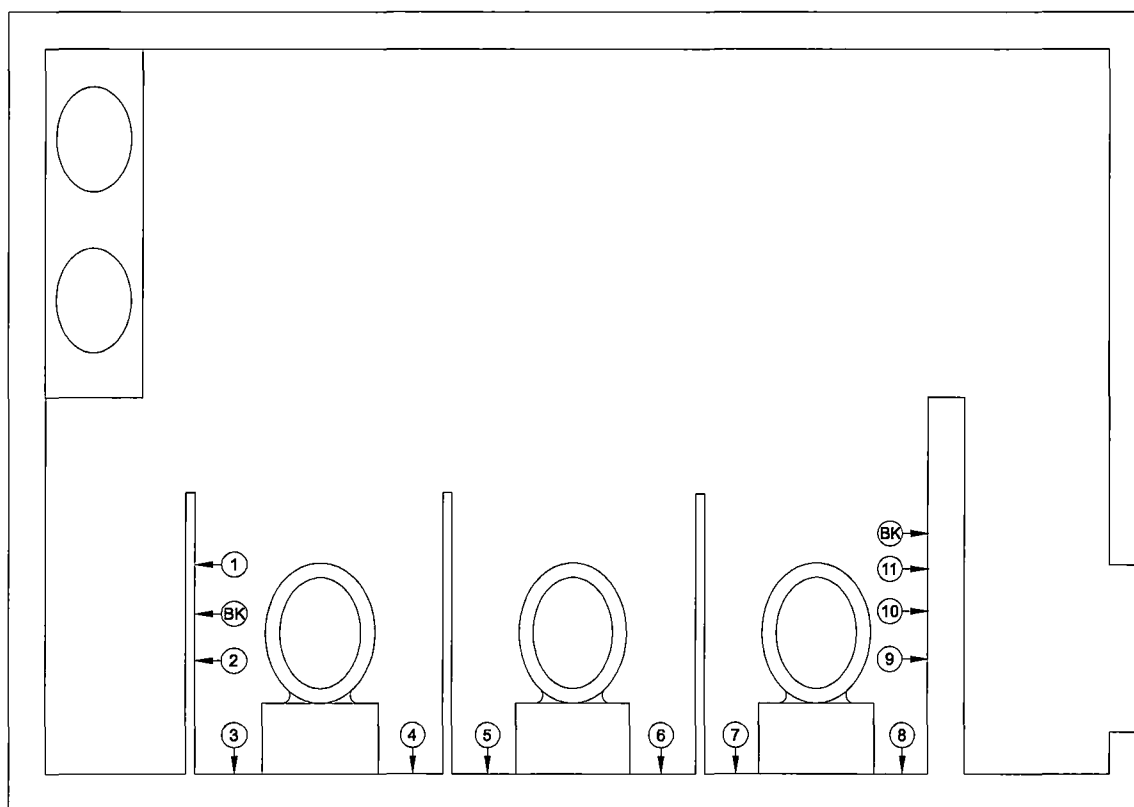
2nd Floor Men's Bathroom  
Tile Wall  
Background Survey  
04WS1

⊗ Approximate location of survey point.



2nd Floor Men's Bathroom  
Tile Wall  
Background Survey  
04WS1

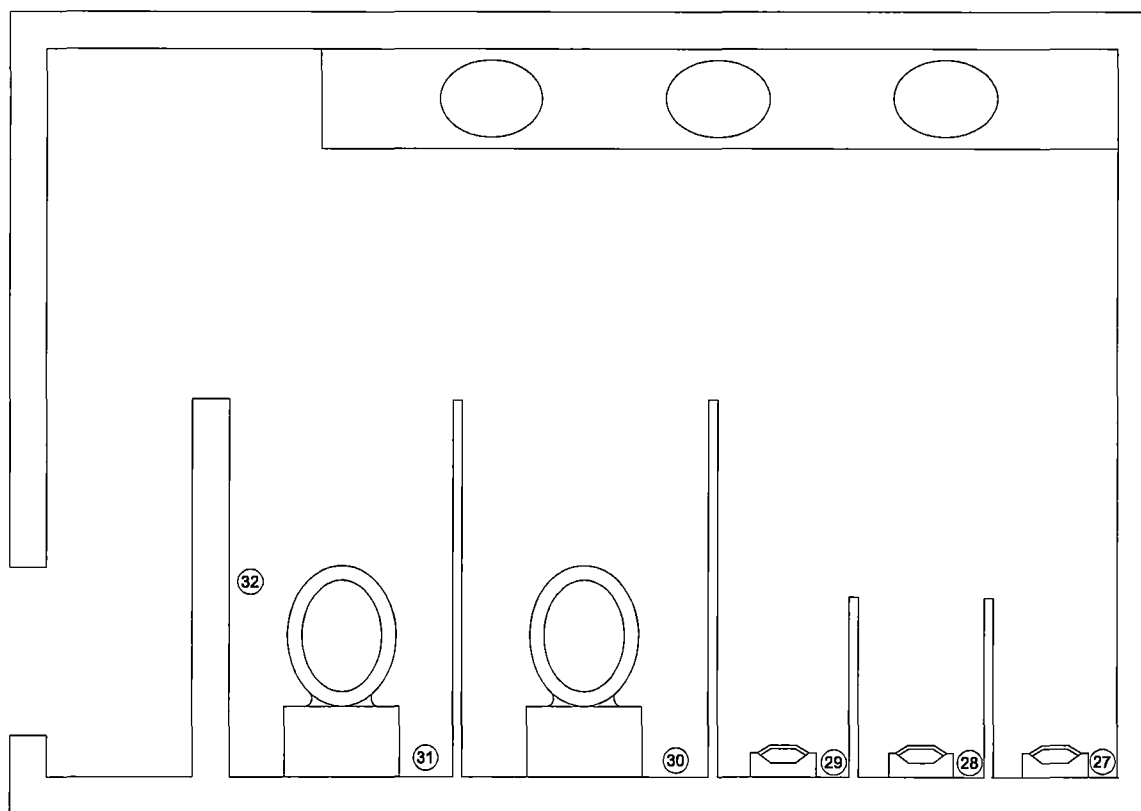
⊗ Approximate location of survey point.



3rd Floor Women's Bathroom  
Tile Wall  
Background Survey

⊗ Approximate location of survey point.





4th Floor Men's Bathroom  
Tile Wall  
Background Survey  
04WS1

⊗ Approximate location of survey point.

**ATTACHMENT 2F**

**Analysis of Concrete Sample Variance**

## Concrete Core Data Variance Analysis

### Introduction

A series of concrete core samples were collected and analyzed<sup>1</sup> as described in Engineering Calculation 011-01(MY) to determine the radionuclide mixture to use in the DCGL calculation for contaminated concrete and other contaminated materials. The nuclide mixture determination included an analysis of the data to ensure that the established dose criterion will be satisfied with sufficient confidence when the selected mixture was used. This analysis was performed primarily on the basis of dose.

This attachment describes the process used to evaluate the nuclide mixture for contaminated concrete surfaces and to determine that the mixture is representative and ensures that the established dose criterion will be met with sufficient confidence.

### Nuclide Data

The concrete core data used to determine the nuclide mixture was collected during two sampling campaigns. The first data set was comprised of seven cores collected during the site characterization that were representative of concrete contamination in the majority of plant areas. This majority area is called the "balance of plant" (BOP). The first data set was used to determine the nuclide fractions for the BOP, which includes most of the areas in the building basements.

A second data set, consisting of eight samples, was collected to replace cores consumed during analysis processes, to investigate suspect data, and to provide additional information on the nuclide mixture in certain areas that had some potential for containing nuclide mixtures that differed from the BOP. The second data set consisted of two cores from the Containment Outer Annulus (O/A) trench, three cores from within the loops of Containment, and three cores from the Primary Auxiliary Building (PAB). See Tables 1 and 5 for the listing of actual core identification numbers and the associated plant locations. (Location maps are included in Engineering Calculation EC-011-01 (MY).)

### Conversion of BOP Concrete Core Analytical Results to Dose

The first step in determining the acceptability of the BOP nuclide mixture was to normalize<sup>2</sup> the nuclide data and convert the normalized data to dose. Dose was used in the evaluation since the unrestricted use criterion is defined in terms of dose and expressing potential uncertainty in terms of dose provides the most direct means of demonstrating acceptability.

There were several steps required to convert the raw radioanalytical core data to dose. First, the nuclide data for each core was decay corrected to 1/1/2004 to correspond to the approximate

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<sup>1</sup> Core analyses were performed by Duke Engineering and Services Environmental Laboratory

<sup>2</sup> Normalization, in this case refers to converting the reported nuclide concentration results into nuclide fractions.

time of the last final surveys. The initial and decay corrected data as well as other supporting documents is provided in EC-011-01. Second, the decay corrected nuclide concentration results from each of the cores were converted to fractions. The sum of the nuclide fractions in each core then represent 1.0 dpm/100 cm<sup>2</sup> total activity. Analytical results that were reported as less than the minimum detectable activity (MDA) were assumed to be present at the MDA value in the initial review. The nuclides that were listed as less than MDA in each of the seven cores are indicated in Table 1 by a "<" sign. See Table 1, Column 3 for example of normalized nuclide fractions for the core 1FL1.

The basement fill model (LTP Section 6.6.1) was used to convert the normalized nuclide fractions to dose. Note that there were two other materials, i.e., buried pipe/conduit and embedded pipe, that were assumed to contain the BOP nuclide mixture and each of these materials has a different dose model. However, because the basement concrete contains the overwhelming majority of the contamination inventory and results in the highest dose, the basement fill model was selected for the core dose calculations.

The dose was calculated by multiplying the normalized nuclide fractions by the unitized dose factors determined in Engineering Calculation EC-011-01 (MY). The unitized dose factor is the dose that would result from 1.0 dpm/100 cm<sup>2</sup> activity of a given radionuclide. See Table 1, Column 4 for an example of the dose from the nuclide fractions in the Core 1FL1 mixture.

The sum of the normalized doses from all radionuclides in a given core represents the dose from each core assuming that the core contains a total activity of 1.0 dpm/100 cm<sup>2</sup>. The last conversion required to perform the analysis of uncertainty in the radionuclide mixture is to convert the 1.0 dpm/100 cm<sup>2</sup> normalized doses to a dose that represents 18,000 dpm/100 cm<sup>2</sup> detectable beta activity. This is accomplished by dividing each of the nuclides in a given core by the detectable beta fraction of the core and multiplying by 18,000 dpm/100 cm<sup>2</sup>. This conversion allows direct comparison with the dose that would result if residual contamination were present in each core at the DCGL concentrations of 18,000 dpm/100 cm<sup>2</sup> observable data. See Table 1, Column 5 for an example of the nuclide dose from core 1FL1 after converting to 18,000 dpm/100 cm<sup>2</sup>.

The use of the various dose-converted core data sets in the evaluation of core variability is described in the sections below.

### **Evaluation of Less than MDA Nuclides**

Before the nuclide data variability could be evaluated, the results reported as less than MDA were considered. It was expected that several of the 31 nuclides would be reported as less than MDA since these nuclides have a low probability of being present and were included in the analyses only as a conservative measure. Two approaches were considered for evaluating MDA results; 1) include the MDA values as representing actual concentrations, and 2) remove the non-detected nuclides from the mixture. Removing the nuclides was considered more appropriate and representative of actual site conditions because the non-detected nuclides are believed either to not be present or to be present at concentrations well below the reported MDA value.

However, it cannot be ruled out with 100% certainty that the non-detected nuclides are not present at activities approaching the MDA values. Therefore, an analysis was performed, based on relative dose, to review the affect of leaving the MDA's in the mixture versus removing the MDA's.

To perform this analysis, the dose from the MDA nuclides was compared to the total dose including all nuclides. A nuclide was included in the "MDA" category if it was not detected in any of the cores. If a nuclide was detected in one or more cores, the nuclide was retained and included in the mixture calculation, including MDA values in some instances. For example, Sr-90 was detected above MDA in three of the seven primary cores. For the remaining 4 cores, the MDA value was conservatively assumed to represent detectable activity. As shown in Table 2, the MDA nuclides contributed 1.8% of the total dose ( $5.1\text{E-}03 \text{ mrem/y}/2.8\text{E-}01 \text{ mrem/y}$ ). Since the MDA contribution was low the MDA nuclides were removed from the mixture.

Table 3 contains the nuclide mixture after the MDA nuclides were removed. Note that the nuclide fractions listed in Table 3 was renormalized to 1.0 after removal of the MDA radionuclides that were not detected in any of the cores. This is a conservative yet appropriate approach since the MDA radionuclides were not believed to be present in appreciable quantities.

#### **Evaluation of Variability of Dose from Primary Seven Core Data Set**

The variability of the dose from the cores in the primary seven core data set, after removal of MDA's, was evaluated to demonstrate that the variability is low relative to the unrestricted use dose criteria of 10 mrem/yr all pathways and that the seven core data set is sufficiently representative of BOP areas. The variability was evaluated by reviewing the dose from individual cores and the dose from the average of the nuclide fractions. The mean and standard deviation of the dose from both the individual cores and the nuclide fractions were evaluated to determine: 1) if there were a significant difference in the means calculated using the two methods, 2) whether any individual core dose appeared to be significantly different from the mean dose, and 3) whether the variability of the mean dose using the average of the fractions method was sufficiently low relative to the 10 mrem/yr all pathways unrestricted use criteria to provide confidence that the dose criterion would be satisfied using the average of the fractions method.

#### **Calculation of Mean and Standard Deviation**

The mean dose and standard deviation of the mean from the individual seven cores were calculated using the data set generated after removal of MDAs and converting to 18,000 dpm measurable gross beta (See Table 4). The calculation of the standard deviation of the mean from the individual cores used the following standard equations:

$$\sqrt{\frac{n\sum x^2 - (\sum x)^2}{n(n-1)}}$$

then,

$$\frac{\text{Standard Deviation}}{\sqrt{n}}$$

The mean dose and standard deviation of the mean from the nuclide fractions in the seven cores were calculated using the data set generated after removal of MDA's but before converting to 18,000 dpm/100 cm<sup>2</sup> measurable gross beta. Use of this data set was required because the relative nuclide fractions found in the original core analyses need to be retained to correctly calculate the average of the nuclide fractions over the seven cores. After the dose from average nuclide fractions was calculated the result was converted to represent the dose from 18,000 dpm/100 cm<sup>2</sup> measurable gross beta prior to comparison of the two data sets.

The mean dose from the nuclide fractions was calculated by summing the dose from average of each nuclide fraction over the seven cores. The standard deviation of the mean dose from the nuclide fractions required the use of a standard propagation of errors equation to account for the variability within each average nuclide fraction. This was accomplished by squaring the standard deviation of each average nuclide fraction and summing over all nuclides. The propagated error was calculated as:

$$\sqrt{\sum \left( \frac{\text{std. dev}}{\sqrt{n}} \right)^2}$$

The first and second data sets were evaluated and compared to ensure that there was not a significant variation between the average dose from the individual cores, which is assumed to represent a given area of the plant, and the average dose as represented by the nuclide fractions in the BOP mixture listed in the LTP.

#### Data Evaluation

The first evaluation of the individual core and nuclide fractions data sets was performed to demonstrate that there was no significant difference between the means of the two methods for calculating mean dose. It is obvious by a simple comparison of the means and standard deviations provided in Table 4 that there is not a significant difference between the means. The mean dose and standard deviation for the individual cores are 0.29 mrem/yr and 0.030 mrem/yr, respectively. The mean dose and standard deviation using the average of the fractions method are 0.30 mrem/yr and 0.070 mrem/yr, respectively. In fact, the means are essentially identical, differing by less than 0.01 mrem/yr.

The second evaluation entailed a review of the individual core data set to determine if any individual core dose was significantly different from the mean. The standard deviation of the individual core dose, 0.083 mrem/yr, was used for this evaluation. Multiplying the standard deviation by 1.96 and then adding and subtracting the result to the mean results in the upper and lower 95% confidence level bounds. The upper confidence level was 0.46 mrem/yr and the

lower confidence level was 0.13 mrem/yr. No individual core dose was outside the 95% confidence levels indicating that no area represented by the core dose was significantly different from the mean. Note that core 02FL51 was at the upper confidence level. This is attributable to an unusually high MDA value for Sr-90 in this core relative to the Sr-90 MDA values reported for the 4 other cores where MDA values were applied and is therefore not significant.

The third evaluation was to review the distribution of the mean from the average of the fractions method. As seen in Table 4, upper 95% confidence level is 0.14 mrem/yr (0.07 mrem/yr times 1.96), which is a very small fraction of the of the 10 mrem/yr dose criterion.

The results of the three evaluations performed above demonstrate: 1) that there is no significant difference between the individual core and average of the fractions methods for calculating mean dose, 2) that no individual core varied significantly from the mean indicating that all of the cores were a part of the same population, and 3) that the variability of the dose using the average of the fractions method is a small fraction of the unrestricted use limit and ensures that the dose criterion will be met with sufficient confidence.

#### **Methods for Evaluating Additional Eight Cores**

The discussions and analyses presented above demonstrate that the seven core data set is sufficient to determine the BOP nuclide mixture. The next task was to develop the methods to evaluate the nuclide mixtures in the eight additional cores that were collected during continuing characterization and determine whether they were consistent with the BOP mixture.

If the nuclide mixture of a given core is significantly different from the BOP mixture, then a separate mixture and DCGL may be necessary for the areas represented by the cores. These evaluation criteria would also apply to additional concrete cores collected, if any. Based on evaluation of the 15 cores and a review of the potential for additional plant areas to have a significantly different nuclide mixture than the BOP, no additional cores are deemed necessary to support the LTP.

Three factors were considered in the evaluation of additional cores: 1) whether the core contained detectable transuranics, 2) whether one or more radionuclide fractions are significantly different from the BOP mixture, and 3) whether the dose from an additional core was significantly different from the BOP mixture dose and exceeded 1.0 mrem/yr. The three evaluation factors were developed during the Technical Issue Resolution Process (TIRP) conducted by the State of Maine and Maine Yankee as a part of the Settlement Agreement related to the States motion to terminate their petition to intervene in the matter of MY's proposed LTP. During the TIRP, MY and State technical experts developed and used these three criteria to evaluate additional concrete core samples. Maine Yankee believes the criteria are reasonable and protective and agreed to include the criteria in the LTP. The three criteria for evaluating individual cores are listed below.

1. No detectable TRU.



2. Individual fractions of nuclides:

Nuclide	Maximum Nuclide Fraction
Sr	0.013
Co	0.170
Cs	1.000
Ni	1.000

3. Individual core total dose from all nuclide fractions less than 1.0 mrem/yr.

The first individual core criterion (#1 above) pertained to transuranic (TRU) radionuclides. The TRU's were singled out because their radiological and chemical characteristics differ from the BOP radionuclide mixture, as well as the fact that there is a significant level of stakeholder interest in TRU's. Therefore, the first individual core decision statement was whether or not the core contained TRU's at levels exceeding the minimum detectable activity (MDA). If so, the area represented by the core would either 1) be subject to a unique radionuclide mixture and DCGL or 2) be combined with other TRU cores to generate a single radionuclide mixture and DCGL representing several TRU affected areas.

The second individual core criterion (#2 above) compares the radionuclide fractions in a given core to an upper bound expected given the data provided in the seven-core BOP set. The upper 95% confidence level (UCL) was calculated for each nuclide fraction in the seven core set. The UCL's for four nuclides, Cs-137, Co-60, Sr-90, and Ni-63 are listed above as individual core Criterion #2. Criterion #2 was limited to these four nuclides since they together comprise the overwhelming majority of the dose from concrete basement surfaces. If the nuclide fractions in a given individual core are all less than the values listed in Criterion #2, the BOP radionuclide fraction set is assumed to sufficiently represent the core. However, if an individual core contains a nuclide fraction equal to or exceeding one of the values listed in Criterion #2, then the dose from the core must be calculated and compared to the dose listed in individual core Criterion #3 (#3 above). Criterion # 2 only applies to nuclide fractions that are based upon nuclide activities greater than MDA. If a core's radionuclide fraction, which is based upon a radionuclide activity less than MDA, fails to meet Criterion #2 and the MDA is comparable to the MDA's achieved for the other cores, then it will be considered as having satisfied Criterion #2 for that radionuclide.

The third individual core criterion (#3 above) ensures that the dose potentially represented by an individual core is not significantly different from the seven-core data set. Criterion #3 is required only if Criterion #2 is not satisfied. The dose criterion of 1.0 mrem/yr was selected because at the time of the TIRP original consensus 1.0 mrem/yr was 0.44 mrem/yr above the mean dose (0.556 mrem/yr) calculated using the BOP nuclide mixture. Using the most current dose assessment results, 1 mrem/yr is 0.70 mrem/y above the mean dose of 0.30 mrem/y. The current 0.70 mrem/yr value is more conservative than the 0.44 mrem/yr value found to be acceptable by the TIRP since the actual core variability is a smaller percentage of the acceptable 0.70 mrem/yr variability. A variability of either 0.44 or 0.70 mrem/y above the mean is well below the value that would be acceptable by NRC guidance in NUREG-1727, Page E16, which states that "...the

presence of nuclides that likely contribute less than 10% of the total effective dose equivalent may be ignored.” The Maine Yankee dose limit is 10 mrem/yr and 10% equals 1.0 mrem/yr. Use of such a 10% criterion is also supported by NRC regulations in 10 CFR 20.1204(g) and 10 CFR 20.1502. Note that the value of 0.70 mrem/yr represents the variability attributable to uncertainty in the nuclide mixture for the individual concrete cores and not an actual dose above the 10 mrem/yr limit. The best estimate of dose is calculated using the mean nuclide fractions of the seven-core data set, i.e., the BOP nuclide mixture.

### **Results of Evaluation of Eight Additional Cores**

The analytical results for the eight additional cores are provided in Table 5. The data was reduced in the same manner as the primary seven core data set. Each radionuclide was decay corrected to 2004; the nuclide fractions were normalized to 1.0; the nuclide fractions were then multiplied by the unitized dose factors based on 1.0 dpm/100 cm<sup>2</sup> (to convert the fractions to dose); and finally, the dose was converted to that which would result from 18,000 dpm/100 cm<sup>2</sup> measurable gross beta. The data for the individual cores was then compared to the three evaluation criteria described above.

Inspection of Table 5 shows that four of the cores clearly meet the 3 evaluation criteria and are considered to be sufficiently represented by the BOP nuclide mixture. These cores were collected from the Containment loops 1, 2, and 3, and the PAB evaporator cubicle and show good agreement with the BOP mixture.

Of the remaining four cores, two of the cores were from the O/A trench and two are from the PAB pipe tunnel. Three of the four cores contained TRU's that were above the MDA. Table 6 contains the radionuclide mixture and dose data for the four TRU affected cores after removal of the MDA results. Table 7 contains the dose summaries for the individual core and average of the fractions methods for the TRU affected cores. The individual core doses range from 0.18 to 0.25 mrem/yr assuming 18,000 dpm/100 cm<sup>2</sup> observable beta. This is a very low fraction of the unrestricted use criteria and is much less than the 1.0 mrem/yr individual core dose criteria used in the BOP nuclide mixture decision rule. As stated previously, the data reduction method for these four cores was conducted in the same manner as for the BOP cores. The dose from the four cores TRU mixture using the average of the fractions method was 0.21 mrem/yr. Based on these results, the four core “average of the fractions” nuclide mixture will be used to determine a separate DCGL for “TRU Affected” areas hereafter referred to as “Special Areas”.

After the identification of Special Areas through the analyses of the eight additional cores, a review of building basement areas was performed to determine if there were other areas that could be designated as Special Areas that were not represented by the BOP mixture. The liquid waste stream significantly impacted both the O/A trench and PAB pipe tunnel. The O/A trench captured all water released to the floor of the Containment building and routed it to the Containment sump. The PAB pipe tunnel held the pipes that carried the liquid waste water being processed by the filters and demineralizers in the PAB. Both areas had standing water and boron encrustations during plant operation. As a result of this review one additional area (letdown heat exchanger cubicle) was identified that had operating history and characteristics

that were sufficiently similar to the PAB pipe tunnel and Containment O/Annulus Trench to warrant consideration as TRU affected.

The letdown heat exchanger cubicle is an area of approximately 2.5 m by 2.5 m by 3 m tall located in the PAB basement. Because of its small size, it was not specifically sampled. This is the one area that stands out as perhaps needing to be examined since it was processed high temperature liquids and had standing boron. Additional cores samples could have been collected in the letdown heat exchanger cubicle to demonstrate that the cubicle is not TRU affected and that the BOP nuclide mixture would apply. However, the decision was made to conservatively assume the area was TRU affected and to use the "Special Area" nuclide mixture to calculate the DCGL for this area. This decision is conservative since the DCGL for Special Areas is lower than the BOP areas.

## **Conclusion**

The nuclide mixture provided in Table 4 Column 2 using the average of the fractions methods has been demonstrated to be representative of BOP areas and ensures that the established dose criterion will be satisfied with sufficient confidence. Three TRU affected areas have been identified that are represented by a unique nuclide mixture as listed in Table 7 Column 2. Finally a decision rule has been developed through the cooperative efforts of the State of Maine and Maine Yankee (i. e., TIRP). This rule will be used to evaluate the impact and use of any future core information obtained with regard to nuclide mixture and the associated DCGL.

## **References**

1. Maine Yankee License Termination Plan Settlement Agreement, ASLNP No. 00-870-03-OLA, August 29, 2001.
2. Participant Consensus Agreement, State of Maine – Maine Yankee Settlement Agreement, Technical Issue Resolution Process, Dated December 13, 2001.

**Table 1**  
**Nuclide Fractions and Dose (mrem/y) for Balance of Plant Core Samples**  
 (Table 1 page 1 of 2)

**Attachment 2F**  
**Analysis of Concrete Sample Variance**  
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Column # ==>	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		PAB 11' West Pipe Trench 1FL1		Dose For 1.80E+04 dpm/100 cm <sup>2</sup>		Fuel Bldg Decon Room 01FL31		Dose For 1.80E+04 dpm/100 cm <sup>2</sup>		Spray Bldg 11' 01FL41		Dose For 1.80E+04 dpm/100 cm <sup>2</sup>		RCA Bldg 21' 01FL61		Dose For 1.80E+04 dpm/100 cm <sup>2</sup>
		2004	1 dpm dose	detectable β		2004	1 dpm dose	detectable β		2004	1 dpm dose	detectable β		2004	1 dpm dose	detectable β
Nuclide		nf	Times nf	2004		nf	Times nf	2004		nf	Times nf	2004		nf	Times nf	2004
H-3		3.997E-04	1.34E-08	9.59E-04		6.265E-04	2.10E-08	4.84E-04		1.211E-03	4.06E-08	4.85E-03		1.025E-03	3.43E-08	7.08E-04
C-14	<	3.433E-06	6.19E-11	4.43E-06	<	1.067E-04	1.92E-09	4.44E-05	<	1.531E-04	2.76E-09	3.30E-04	<	3.590E-05	6.47E-10	1.33E-05
Mn-54	<	1.369E-04	2.88E-10	2.06E-05	<	1.326E-04	2.79E-10	6.43E-06	<	1.533E-04	3.22E-10	3.86E-05	<	1.098E-04	2.31E-10	4.76E-06
Fe-55		2.855E-03	1.67E-09	1.19E-04		4.571E-04	2.67E-10	6.16E-06		3.800E-03	2.22E-09	2.65E-04		2.896E-03	1.69E-09	3.49E-05
Co-57		2.861E-05	7.26E-12	5.20E-07	<	9.019E-05	2.29E-11	5.27E-07	<	9.928E-05	2.52E-11	3.01E-06	<	5.719E-05	1.45E-11	2.99E-07
Co-58	<	5.437E-10	4.40E-16	3.15E-11	<	4.137E-10	3.34E-16	7.71E-12	<	5.137E-10	4.15E-16	4.97E-11	<	3.427E-10	2.77E-16	5.71E-12
Ni-59	<	7.594E-03	9.18E-11	6.57E-06	<	2.152E-03	2.60E-11	6.00E-07	<	8.586E-03	1.04E-10	1.24E-05	<	1.223E-03	1.48E-11	3.04E-07
Co-60		1.539E-01	9.70E-07	6.95E-02		4.057E-03	2.56E-08	5.90E-04		3.125E-02	1.97E-07	2.36E-02		2.692E-02	1.70E-07	3.50E-03
Ni-63		7.357E-01	8.22E-08	5.89E-03		2.085E-01	2.33E-08	5.37E-04		8.318E-01	9.29E-08	1.11E-02		1.184E-01	1.32E-08	2.73E-04
Zn-65	<	1.324E-04	1.40E-09	1.00E-04	<	1.383E-04	1.46E-09	3.37E-05	<	2.214E-04	2.34E-09	2.80E-04	<	8.986E-05	9.50E-10	1.96E-05
Sr-90		1.316E-04	8.30E-09	5.95E-04	<	1.198E-03	7.56E-08	1.74E-03		5.420E-04	3.42E-08	4.09E-03		1.267E-03	8.00E-08	1.65E-03
Nb-94	<	5.978E-03	1.00E-08	7.17E-04	<	3.825E-03	6.40E-09	1.48E-04	<	9.049E-03	1.51E-08	1.81E-03	<	3.867E-03	6.47E-09	1.33E-04
Tc-99	<	1.520E-05	4.89E-09	3.50E-04	<	1.409E-04	4.53E-08	1.04E-03	<	1.547E-05	4.97E-09	5.95E-04	<	1.558E-04	5.01E-08	1.03E-03
Ru-106	<	1.742E-03	2.15E-08	1.54E-03	<	3.616E-03	4.45E-08	1.03E-03	<	3.178E-03	3.91E-08	4.68E-03	<	2.158E-03	2.66E-08	5.48E-04
Ag-110m	<	1.003E-04	3.46E-10	2.48E-05	<	7.361E-05	2.54E-10	5.85E-06	<	1.228E-04	4.23E-10	5.06E-05	<	5.515E-05	1.90E-10	3.92E-06
Sb-125	<	3.596E-03	7.22E-09	5.17E-04	<	1.165E-02	2.34E-08	5.39E-04	<	7.372E-03	1.48E-08	1.77E-03	<	7.898E-03	1.59E-08	3.27E-04
I-129	<	3.032E-08	1.97E-10	1.41E-05	<	2.810E-07	1.82E-09	4.20E-05	<	3.084E-08	2.00E-10	2.39E-05	<	3.107E-07	2.02E-09	4.15E-05
Cs-134		1.720E-03	4.10E-08	2.94E-03	<	1.264E-03	3.01E-08	6.95E-04	<	2.039E-03	4.86E-08	5.81E-03		1.835E-03	4.38E-08	9.01E-04
Cs-137		8.049E-02	1.29E-06	9.25E-02		7.461E-01	1.20E-05	2.76E-01		8.188E-02	1.31E-06	1.57E-01		8.250E-01	1.32E-05	2.73E-01
Ce-144	<	3.222E-04	3.34E-10	2.39E-05	<	9.153E-04	9.49E-10	2.19E-05	<	9.014E-04	9.34E-10	1.12E-04	<	5.599E-04	5.80E-10	1.20E-05
Pm-147	<	5.086E-06	1.03E-11	7.39E-07	<	2.762E-04	5.60E-10	1.29E-05	<	2.629E-05	5.33E-11	6.38E-06	<	2.761E-05	5.60E-11	1.15E-06
Eu-154	<	2.749E-03	2.11E-09	1.51E-04	<	3.889E-03	2.99E-09	6.89E-05	<	9.220E-03	7.09E-09	8.48E-04	<	1.685E-03	1.30E-09	2.67E-05
Eu-155	<	2.347E-03	2.31E-10	1.65E-05	<	7.394E-03	7.27E-10	1.68E-05	<	7.950E-03	7.81E-10	9.34E-05	<	4.368E-03	4.29E-10	8.85E-06
Pu-238	<	8.588E-07	1.20E-10	8.56E-06	<	1.537E-05	2.14E-09	4.93E-05	<	1.768E-05	2.46E-09	2.94E-04	<	5.462E-06	7.60E-10	1.57E-05
Pu-239	<	4.261E-07	6.56E-11	4.70E-06	<	5.260E-06	8.10E-10	1.87E-05	<	7.773E-06	1.20E-09	1.43E-04	<	2.728E-06	4.20E-10	8.65E-06
Pu-240	<	4.259E-07	6.56E-11	4.70E-06	<	5.258E-06	8.10E-10	1.87E-05	<	7.771E-06	1.20E-09	1.43E-04	<	2.727E-06	4.20E-10	8.65E-06
Pu-241	<	6.122E-05	1.83E-10	1.31E-05	<	3.324E-03	9.92E-09	2.29E-04	<	3.164E-04	9.44E-10	1.13E-04	<	3.324E-04	9.92E-10	2.04E-05
Am-241	<	1.768E-06	8.24E-11	5.90E-06	<	3.481E-05	1.62E-09	3.74E-05	<	2.304E-05	1.07E-09	1.28E-04	<	8.914E-06	4.15E-10	8.55E-06
Cm-242	<	6.341E-10	4.44E-16	3.18E-11	<	1.225E-08	8.58E-15	1.98E-10	<	8.724E-09	6.11E-15	7.31E-10	<	3.500E-09	2.45E-15	5.05E-11
Cm-243	<	3.641E-07	5.57E-12	3.99E-07	<	5.775E-06	8.84E-11	2.04E-06	<	4.878E-06	7.47E-11	8.93E-06	<	1.823E-06	2.79E-11	5.75E-07
Cm-244	<	3.416E-07	4.21E-12	3.01E-07	<	5.418E-06	6.67E-11	1.54E-06	<	4.576E-06	5.64E-11	6.74E-06	<	1.710E-06	2.11E-11	4.34E-07
sum		1.000E+00				1.000E+00				1.000E+00				1.000E+00		
obs. β fraction		2.513E-01				7.809E-01				1.505E-01				8.736E-01		



**Table 2**  
**Calculation of Dose From MDA Nuclides**

Column # ==>	2	3	4	5	6	7	8	9	10	11
	<b>Dose Results (in mrem/y) for Average of the Fractions (1.0 dpm)</b>									
<b>Nuclide</b>	<b>1FL1</b>	<b>01FL31</b>	<b>01FL41</b>	<b>01FL61</b>	<b>01FL81</b>	<b>02FL21</b>	<b>02FL51</b>	<b>mean*</b>	<b>stdev mean</b>	<b>(stdev Mean)<sup>2</sup></b>
<b>H-3</b>	1.34E-08	2.10E-08	4.06E-08	3.43E-08	1.20E-07	1.43E-07	4.07E-06	1.81E-02	1.629E-02	2.65E-04
<b>C-14</b>	6.19E-11	1.92E-09	2.76E-09	6.47E-10	1.73E-09	2.40E-09	4.36E-08	2.16E-04	1.712E-04	2.93E-08
<b>Mn-54</b>	2.88E-10	2.79E-10	3.22E-10	2.31E-10	2.52E-10	4.32E-10	2.85E-09	1.89E-05	1.040E-05	1.08E-10
<b>Fe-55</b>	1.67E-09	2.67E-10	2.22E-09	1.69E-09	1.39E-09	3.06E-10	9.61E-09	6.98E-05	3.488E-05	1.22E-09
<b>Co-57</b>	7.26E-12	2.29E-11	2.52E-11	1.45E-11	1.64E-11	2.94E-11	3.57E-10	1.92E-06	1.377E-06	1.90E-12
<b>Co-58</b>	4.40E-16	3.34E-16	4.15E-16	2.77E-16	3.53E-16	5.30E-16	9.18E-15	4.69E-11	3.574E-11	1.28E-21
<b>Ni-59</b>	9.18E-11	2.60E-11	1.04E-10	1.48E-11	2.17E-11	1.93E-12	3.20E-11	1.19E-06	4.261E-07	1.82E-13
<b>Co-60</b>	9.70E-07	2.56E-08	1.97E-07	1.70E-07	3.18E-07	3.78E-08	6.52E-07	9.64E-03	3.765E-03	1.42E-05
<b>Ni-63</b>	8.22E-08	2.33E-08	9.29E-08	1.32E-08	1.94E-08	1.72E-09	2.87E-08	1.06E-03	3.816E-04	1.46E-07
<b>Zn-65</b>	1.40E-09	1.46E-09	2.34E-09	9.50E-10	1.55E-09	1.59E-09	4.01E-08	2.01E-04	1.569E-04	2.46E-08
<b>Sr-90</b>	8.31E-09	7.56E-08	3.42E-08	8.00E-08	2.77E-08	2.42E-08	7.74E-07	4.16E-03	2.992E-03	8.95E-06
<b>Nb-94</b>	1.00E-08	6.40E-09	1.51E-08	6.47E-09	8.88E-09	7.87E-09	8.79E-08	5.80E-04	3.217E-04	1.04E-07
<b>Tc-99</b>	4.89E-09	4.53E-08	4.97E-09	5.01E-08	4.50E-08	5.67E-08	1.59E-08	9.06E-04	2.408E-04	5.80E-08
<b>Ru-106</b>	2.15E-08	4.45E-08	3.91E-08	2.66E-08	3.12E-08	4.10E-08	6.15E-08	1.08E-03	1.427E-04	2.03E-08
<b>Ag-110m</b>	3.46E-10	2.54E-10	4.23E-10	1.90E-10	3.11E-10	2.44E-10	4.55E-09	2.57E-05	1.731E-05	3.00E-10
<b>Sb-125</b>	7.22E-09	2.34E-08	1.48E-08	1.59E-08	1.56E-08	2.74E-08	1.67E-07	1.10E-03	6.138E-04	3.77E-07
<b>I-129</b>	1.97E-10	1.82E-09	2.00E-10	2.02E-09	1.81E-09	2.28E-09	6.42E-10	3.65E-05	9.688E-06	9.39E-11
<b>Cs-134</b>	4.10E-08	3.01E-08	4.86E-08	4.38E-08	3.70E-08	3.66E-08	4.17E-07	2.66E-03	1.537E-03	2.36E-06
<b>Cs-137</b>	1.29E-06	1.20E-05	1.31E-06	1.32E-05	1.19E-05	1.50E-05	4.21E-06	2.40E-01	6.364E-02	4.05E-03
<b>Ce-144</b>	3.34E-10	9.49E-10	9.34E-10	5.80E-10	6.79E-10	1.25E-09	1.43E-08	7.73E-05	5.500E-05	3.03E-09
<b>Pm-147</b>	1.03E-11	5.60E-10	5.33E-11	5.60E-11	5.24E-11	1.80E-10	1.73E-09	1.08E-05	6.750E-06	4.56E-11
<b>Eu-154</b>	2.11E-09	2.99E-09	7.09E-09	1.30E-09	2.73E-09	3.62E-09	1.61E-08	1.46E-04	5.560E-05	3.09E-09
<b>Eu-155</b>	2.31E-10	7.27E-10	7.81E-10	4.29E-10	4.97E-10	8.69E-10	8.82E-10	1.80E-05	2.671E-06	7.14E-12
<b>Pu-238</b>	1.20E-10	2.14E-09	2.46E-09	7.60E-10	2.05E-09	1.45E-09	3.21E-08	1.67E-04	1.248E-04	1.56E-08
<b>Pu-239</b>	6.56E-11	8.10E-10	1.20E-09	4.20E-10	1.08E-09	7.08E-10	1.35E-08	7.22E-05	5.203E-05	2.71E-09
<b>Pu-240</b>	6.56E-11	8.10E-10	1.20E-09	4.20E-10	1.08E-09	7.08E-10	1.35E-08	7.22E-05	5.201E-05	2.71E-09
<b>Pu-241</b>	1.83E-10	9.92E-09	9.44E-10	9.92E-10	9.28E-10	3.18E-09	3.07E-08	1.91E-04	1.196E-04	1.43E-08
<b>Am-241</b>	8.24E-11	1.62E-09	1.07E-09	4.15E-10	1.51E-09	1.04E-09	2.70E-08	1.33E-04	1.059E-04	1.12E-08
<b>Cm-242</b>	4.44E-16	8.58E-15	6.11E-15	2.45E-15	9.23E-15	4.45E-15	1.84E-13	8.74E-10	7.261E-10	5.27E-19
<b>Cm-243</b>	5.58E-12	8.84E-11	7.47E-11	2.79E-11	1.02E-10	5.74E-11	2.00E-09	9.57E-06	7.887E-06	6.22E-11
<b>Cm-244</b>	4.21E-12	6.67E-11	5.64E-11	2.11E-11	7.70E-11	4.33E-11	1.51E-09	7.22E-06	5.953E-06	3.54E-11

\* 1 dpm average value times 18,000/0.6324 (obs average beta fraction) = 2.846E+04

Mean Dose from non-detectable nuclides: 5.07E-03

Mean Dose from detectable (**Bolded**) nuclides: 2.75E-01

**Mean**

2.80E-01

**Standard Deviation of the Mean**

6.59E-02

Table 3  
Nuclide Fractions and Dose After Removal of MDA Nuclides

Column # ==>	2	3	4	5	6	7	8	9	10	11	12	13	23
	PAB 11' West Pipe Trench 1FL1		Dose For 1.80E+04 dpm/100 cm <sup>2</sup>	Fuel Bldg Decon Room 01FL31		Dose For 1.80E+04 dpm/100 cm <sup>2</sup>	Spray Bldg 11' 01FL41		Dose For 1.80E+04 dpm/100 cm <sup>2</sup>	RCA Bldg 21' 01FL61		Dose For 1.80E+04 dpm/100 cm <sup>2</sup>	
	2004	1 dpm dose	detectable β	2004	1 dpm dose	detectable β	2004	1 dpm dose	detectable β	2004	1 dpm dose	detectable β	1.0 dpm
Nuclide	nf	Times nf	2004	nf	Times nf	2004	nf	Times nf	2004	nf	Times nf	2004	dose factor
H-3	4.099E-04	1.373E-08	1.021E-03	6.510E-04	2.181E-08	5.020E-04	1.271E-03	4.260E-08	6.313E-03	1.049E-03	3.514E-08	7.230E-04	3.351E-05
Fe-55	2.928E-03	1.711E-09	1.271E-04	4.750E-04	2.775E-10	6.387E-06	3.988E-03	2.330E-09	3.453E-04	2.963E-03	1.731E-09	3.563E-05	5.843E-07
Co-57	2.934E-05	7.443E-12	5.531E-07	9.373E-05	2.378E-11	5.472E-07	1.042E-04	2.644E-11	3.918E-06	5.851E-05	1.484E-11	3.054E-07	2.537E-07
Co-60	1.578E-01	9.948E-07	7.393E-02	4.216E-03	2.658E-08	6.118E-04	3.280E-02	2.068E-07	3.065E-02	2.754E-02	1.736E-07	3.573E-03	6.305E-06
Ni-63	7.544E-01	8.428E-08	6.263E-03	2.167E-01	2.420E-08	5.571E-04	8.732E-01	9.755E-08	1.446E-02	1.212E-01	1.354E-08	2.786E-04	1.117E-07
Sr-90	1.349E-04	8.514E-09	6.327E-04	1.245E-03	7.857E-08	1.808E-03	5.690E-04	3.590E-08	5.320E-03	1.296E-03	8.180E-08	1.683E-03	6.310E-05
Cs-134	1.763E-03	4.205E-08	3.125E-03	1.313E-03	3.131E-08	7.206E-04	2.140E-03	5.102E-08	7.561E-03	1.877E-03	4.476E-08	9.211E-04	2.384E-05
Cs-137	8.254E-02	1.325E-06	9.847E-02	7.753E-01	1.245E-05	2.865E-01	8.595E-02	1.380E-06	2.045E-01	8.440E-01	1.355E-05	2.788E-01	1.605E-05
sum	1.000E+00			1.000E+00			1.000E+00			1.000E+00			
obs. β fraction	2.422E-01			7.821E-01			1.215E-01			8.748E-01			
avg. β fraction	5.051E-01												

Nuclide Fractions and Dose After Removal of MDA Nuclides (Continued from above)

Column # ==>	14	15	16	17	18	19	20	21	22	23
	PAB 11' Pipe Trench 01FL81		Dose For 1.80E+04 dpm/100 cm <sup>2</sup>	CTMT -2' Loop 2 02FL21		Dose For 1.80E+04 dpm/100 cm <sup>2</sup>	CTMT -2' Loop 1 02FL51		Dose For 1.80E+04 dpm/100 cm <sup>2</sup>	
	2004	1 dpm dose	detectable β	2004	1 dpm dose	detectable β	2004	1 dpm dose	detectable β	1.0 dpm
Nuclide	nf	Times nf	2004	nf	Times nf	2004	nf	Times nf	2004	dose factor
H-3	3.685E-03	1.235E-07	2.726E-03	4.450E-03	1.491E-07	2.742E-03	1.533E-01	5.138E-06	1.850E-01	3.351E-05
Fe-55	2.440E-03	1.425E-09	3.147E-05	5.443E-04	3.180E-10	5.848E-06	2.079E-02	1.215E-08	4.374E-04	5.843E-07
Co-57	6.662E-05	1.690E-11	3.731E-07	1.203E-04	3.053E-11	5.614E-07	1.780E-03	4.515E-10	1.625E-05	2.537E-07
Co-60	5.193E-02	3.274E-07	7.228E-03	6.228E-03	3.927E-08	7.221E-04	1.307E-01	8.240E-07	2.967E-02	6.305E-06
Ni-63	1.785E-01	1.994E-08	4.403E-04	1.605E-02	1.793E-09	3.298E-05	3.241E-01	3.621E-08	1.304E-03	1.117E-07
Sr-90	4.508E-04	2.844E-08	6.280E-04	3.997E-04	2.522E-08	4.638E-04	1.550E-02	9.779E-07	3.521E-02	6.310E-05
Cs-134	1.596E-03	3.806E-08	8.404E-04	1.595E-03	3.803E-08	6.993E-04	2.211E-02	5.271E-07	1.898E-02	2.384E-05
Cs-137	7.613E-01	1.222E-05	2.699E-01	9.706E-01	1.558E-05	2.866E-01	3.317E-01	5.325E-06	1.917E-01	1.605E-05
sum	1.000E+00			1.000E+00			1.000E+00			
obs. β fraction	8.153E-01			9.788E-01			5.000E-01			



**Table 4**  
**Mean and Standard Deviation of Dose**  
**Using the Average of Fractions and Individual Core Methods**

Column # ==>	1	2	3	4	5	6	7	8	9	10	11
	<b>7 Cores</b>							<b>Dose Results (in mrem) for Average of the Fractions (1.0 dpm)</b>			
<b>Nuclide</b>	<b>Mean nf</b>	<b>1FL1</b>	<b>01FL31</b>	<b>01FL41</b>	<b>01FL61</b>	<b>01FL81</b>	<b>02FL21</b>	<b>02FL51</b>	<b>mean*</b>	<b>stdev mean</b>	<b>(stdev Mean)<sup>2</sup></b>
H-3	2.36E-02	1.37E-08	2.18E-08	4.26E-08	3.51E-08	1.23E-07	1.49E-07	5.14E-06	2.30E-02	2.117E-02	4.48E-04
Fe-55	4.81E-03	1.71E-09	2.78E-10	2.33E-09	1.73E-09	1.43E-09	3.18E-10	1.21E-08	8.32E-05	4.602E-05	2.12E-09
Co-57	3.06E-04	7.44E-12	2.38E-11	2.64E-11	1.48E-11	1.69E-11	3.05E-11	4.51E-10	2.38E-06	1.802E-06	3.25E-12
Co-60	5.84E-02	9.95E-07	2.66E-08	2.07E-07	1.74E-07	3.27E-07	3.93E-08	8.24E-07	1.08E-02	4.253E-03	1.81E-05
Ni-63	3.55E-01	8.43E-08	2.42E-08	9.76E-08	1.35E-08	1.99E-08	1.79E-09	3.62E-08	1.16E-03	4.055E-04	1.64E-07
Sr-90	2.80E-03	8.51E-09	7.86E-08	3.59E-08	8.18E-08	2.84E-08	2.52E-08	9.78E-07	5.16E-03	3.912E-03	1.53E-05
Cs-134	4.56E-03	4.20E-08	3.13E-08	5.10E-08	4.48E-08	3.81E-08	3.80E-08	5.27E-07	3.22E-03	2.029E-03	4.12E-06
Cs-137	5.50E-01	1.33E-06	1.24E-05	1.38E-06	1.36E-05	1.22E-05	1.56E-05	5.32E-06	2.58E-01	6.632E-02	4.40E-03

\*.1 dpm average value times 18,000/0.6164 (obs average beta fraction) = 2.920E+04

<b>Mean</b>
3.01E-01
<b>Standard Deviation Of the Mean</b>
6.99E-02

**7 Core Dose Results From Individual Cores 18,000 dpm/100 cm<sup>2</sup> Observable Beta**

	<b>01FL1</b>	<b>01FL31</b>	<b>01FL41</b>	<b>01FL61</b>	<b>01FL81</b>	<b>02FL21</b>	<b>02FL51</b>
<b>Nuclide</b>	<b>2004</b>	<b>2004</b>	<b>2004</b>	<b>2004</b>	<b>2004</b>	<b>2004</b>	<b>2004</b>
H-3	1.02E-03	5.02E-04	6.31E-03	7.23E-04	2.73E-03	2.74E-03	1.85E-01
Fe-55	1.27E-04	6.39E-06	3.45E-04	3.56E-05	3.15E-05	5.85E-06	4.37E-04
Co-57	5.53E-07	5.47E-07	3.92E-06	3.05E-07	3.73E-07	5.61E-07	1.63E-05
Co-60	7.39E-02	6.12E-04	3.06E-02	3.57E-03	7.23E-03	7.22E-04	2.97E-02
Ni-63	6.26E-03	5.57E-04	1.45E-02	2.79E-04	4.40E-04	3.30E-05	1.30E-03
Sr-90	6.33E-04	1.81E-03	5.32E-03	1.68E-03	6.28E-04	4.64E-04	3.52E-02
Cs-134	3.12E-03	7.21E-04	7.56E-03	9.21E-04	8.40E-04	6.99E-04	1.90E-02
Cs-137	9.85E-02	2.86E-01	2.05E-01	2.79E-01	2.70E-01	2.87E-01	1.92E-01
<b>dose sum</b>	<b>1.84E-01</b>	<b>2.91E-01</b>	<b>2.69E-01</b>	<b>2.86E-01</b>	<b>2.82E-01</b>	<b>2.91E-01</b>	<b>4.62E-01</b>

**Individual Core (7) Propagation of Error**

**Mean**

2.95E-01

**Standard Deviation of the Mean**

3.14E-02

**Table 5**  
**Nuclide Fractions and Dose From Eight Additional Cores**  
 (Table 5 page1 of 2)

Column # ==>	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Containment				Containment				Containment				PAB		
		Loop 2		Dose For		Loop 1		Dose For		Loop 3		Dose For		Evaporator		Dose For
		CA9900		1.80E+04		CA9900		1.80E+04		CA9900		1.80E+04		Cubicle		1.80E+04
		12-C003-A		dpm/100 cm <sup>2</sup>		12-C004-A		dpm/100 cm <sup>2</sup>		12-C005-A		dpm/100 cm <sup>2</sup>		13-C001-A		dpm/100 cm <sup>2</sup>
		2004	1 dpm dose	detectable β		2004	1 dpm dose	detectable β		2004	1 dpm dose	detectable β		2004	1 dpm dose	detectable β
Nuclide		nf	Times nf	2004		nf	Times nf	2.00E+03		nf	Times nf	2004		nf	Times nf	2004
H-3		6.299E-03	2.11E-07	4.62E-03		3.601E-02	1.21E-06	2.58E-02		2.101E-03	7.038E-08	1.60E-03		7.211E-02	2.42E-06	5.54E-02
C-14	<	3.284E-04	5.92E-09	1.30E-04	<	8.893E-04	1.60E-08	3.42E-04	<	5.168E-05	9.318E-10	2.11E-05	<	3.268E-02	5.89E-07	1.35E-02
Mn-54		1.329E-05	2.80E-11	6.12E-07		2.928E-05	6.16E-11	1.32E-06	<	5.172E-05	1.088E-10	2.47E-06	<	2.222E-04	4.67E-10	1.07E-05
Fe-55		3.593E-02	2.10E-08	4.60E-04		8.846E-03	5.17E-09	1.10E-04		1.188E-03	6.941E-10	1.58E-05		8.482E-03	4.96E-09	1.14E-04
Co-57	<	2.762E-05	7.01E-12	1.53E-07	<	4.709E-05	1.19E-11	2.55E-07	<	2.070E-04	5.250E-11	1.19E-06	<	7.788E-04	1.98E-10	4.53E-06
Co-58	<	3.161E-09	2.56E-15	5.59E-11	<	3.862E-09	3.12E-15	6.67E-11	<	2.284E-08	1.847E-14	4.19E-10	<	8.250E-08	6.67E-14	1.53E-09
Ni-59	<	1.359E-03	1.64E-11	3.60E-07	<	1.122E-03	1.36E-11	2.90E-07	<	2.046E-03	2.473E-11	5.61E-07	<	1.234E-03	1.49E-11	3.42E-07
Co-60		8.522E-02	5.37E-07	1.18E-02		4.633E-02	2.92E-07	6.24E-03		4.069E-02	2.566E-07	5.82E-03		8.315E-02	5.24E-07	1.20E-02
Ni-63		1.330E-01	1.49E-08	3.25E-04		1.098E-01	1.23E-08	2.62E-04		2.002E-01	2.237E-08	5.08E-04		1.208E-01	1.35E-08	3.10E-04
Zn-65	<	6.124E-06	6.48E-11	1.42E-06	<	1.277E-05	1.35E-10	2.88E-06	<	6.208E-05	6.566E-10	1.49E-05	<	2.748E-04	2.91E-09	6.67E-05
Sr-90		9.839E-04	6.21E-08	1.36E-03		1.330E-03	8.39E-08	1.79E-03		1.131E-03	7.135E-08	1.62E-03	<	4.323E-03	2.73E-07	6.26E-03
Nb-94	<	5.375E-05	9.00E-11	1.97E-06	<	6.424E-05	1.08E-10	2.30E-06	<	4.061E-04	6.798E-10	1.54E-05	<	1.471E-03	2.46E-09	5.65E-05
Tc-99	<	1.338E-04	4.30E-08	9.42E-04	<	1.443E-04	4.64E-08	9.91E-04	<	1.363E-04	4.382E-08	9.94E-04	<	1.177E-04	3.79E-08	8.68E-04
Ru-106	<	9.500E-05	1.17E-09	2.56E-05	<	1.483E-04	1.83E-09	3.90E-05	<	7.091E-04	8.733E-09	1.98E-04	<	2.747E-03	3.38E-08	7.76E-04
Ag-110m	<	1.072E-04	3.70E-10	8.09E-06	<	1.847E-04	6.37E-10	1.36E-05	<	4.383E-05	1.512E-10	3.43E-06	<	2.733E-03	9.43E-09	2.16E-04
Sb-125		2.306E-04	4.63E-10	1.01E-05	<	2.742E-04	5.50E-10	1.18E-05	<	1.229E-03	2.467E-09	5.60E-05	<	4.156E-03	8.34E-09	1.91E-04
I-129	<	2.673E-07	1.73E-09	3.80E-05	<	2.876E-07	1.87E-09	3.99E-05	<	2.718E-07	1.763E-09	4.00E-05	<	2.354E-07	1.53E-09	3.50E-05
Cs-134		1.658E-03	3.95E-08	8.65E-04		2.244E-03	5.35E-08	1.14E-03		1.196E-03	2.851E-08	6.47E-04	<	8.118E-04	1.94E-08	4.44E-04
Cs-137		7.332E-01	1.18E-05	2.58E-01		7.910E-01	1.27E-05	2.71E-01		7.465E-01	1.198E-05	2.72E-01		6.465E-01	1.04E-05	2.38E-01
Ce-144	<	3.068E-05	3.18E-11	6.96E-07	<	5.077E-05	5.26E-11	1.12E-06	<	2.371E-04	2.457E-10	5.58E-06	<	8.396E-04	8.70E-10	2.00E-05
Pm-147	<	9.913E-05	2.01E-10	4.40E-06	<	6.856E-05	1.39E-10	2.97E-06	<	1.939E-05	3.933E-11	8.92E-07	<	7.612E-04	1.54E-09	3.54E-05
Eu-154	<	1.007E-04	7.75E-11	1.70E-06	<	1.202E-04	9.24E-11	1.97E-06	<	7.820E-04	6.014E-10	1.36E-05	<	3.462E-03	2.66E-09	6.11E-05
Eu-155	<	1.068E-04	1.05E-11	2.30E-07	<	1.767E-04	1.74E-11	3.71E-07	<	7.920E-04	7.784E-11	1.77E-06	<	3.559E-03	3.50E-10	8.03E-06
Pu-238	<	1.049E-05	1.46E-09	3.20E-05	<	1.013E-05	1.41E-09	3.01E-05	<	1.550E-06	2.157E-10	4.89E-06	<	1.994E-04	2.78E-08	6.37E-04
Pu-239	<	6.719E-06	1.03E-09	2.26E-05	<	4.201E-06	6.47E-10	1.38E-05	<	1.052E-06	1.620E-10	3.68E-06	<	8.581E-05	1.32E-08	3.03E-04
Pu-240	<	6.718E-06	1.03E-09	2.26E-05	<	4.200E-06	6.47E-10	1.38E-05	<	1.052E-06	1.620E-10	3.68E-06	<	8.579E-05	1.32E-08	3.03E-04
Pu-241	<	8.625E-04	2.57E-09	5.64E-05	<	5.965E-04	1.78E-09	3.80E-05	<	1.687E-04	5.036E-10	1.14E-05	<	6.623E-03	1.98E-08	4.54E-04
Am-241	<	9.807E-05	4.57E-09	1.00E-04	<	3.344E-04	1.56E-08	3.33E-04	<	2.645E-05	1.232E-09	2.80E-05	<	1.383E-03	6.44E-08	1.48E-03
Cm-242	<	5.750E-07	4.03E-13	8.81E-09	<	1.944E-06	1.36E-12	2.91E-08	<	1.638E-07	1.147E-13	2.60E-09	<	8.893E-06	6.23E-12	1.43E-07
Cm-243	<	1.801E-05	2.76E-10	6.04E-06	<	6.190E-05	9.48E-10	2.02E-05	<	4.282E-06	6.555E-11	1.49E-06	<	2.123E-04	3.25E-09	7.46E-05
Cm-244	<	1.725E-05	2.13E-10	4.65E-06	<	5.929E-05	7.30E-10	1.56E-05	<	4.102E-06	5.053E-11	1.15E-06	<	2.034E-04	2.51E-09	5.75E-05
sum		1.000E+00	1.27E-05	2.78E-01		1.000E+00	1.44E-05	3.08E-01		1.000E+00	1.25E-05	2.84E-01		1.000E+00	1.45E-05	3.32E-01
obs. β fraction		8.222E-01				8.429E-01				7.932E-01				7.845E-01		

**Table 5**  
**Nuclide Fractions and Dose From Eight Additional Cores**  
 (Table 5 page 2 of 2)

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	
	PAB			PAB														
	Pipe Tunnel		Dose For	Pipe Tunnel	Dose For	O/A Trench	Dose For	O/A Trench	Dose For	O/A Trench	Dose For	O/A Trench	Dose For	O/A Trench	Dose For	O/A Trench	Dose For	
	CA9900		1.80E+04	CA9900	1.80E+04	CA9900	1.80E+04	CA9900	1.80E+04	CA9900	1.80E+04	CA9900	1.80E+04	CA9900	1.80E+04	CA9900	1.80E+04	
	13-C002-A		dpm/100 cm <sup>2</sup>	13-C003-A	dpm/100 cm <sup>2</sup>	12-C001-A	dpm/100 cm <sup>2</sup>	12-C002-A	dpm/100 cm <sup>2</sup>	12-C002-A	dpm/100 cm <sup>2</sup>	12-C002-A	dpm/100 cm <sup>2</sup>	12-C002-A	dpm/100 cm <sup>2</sup>	12-C002-A	dpm/100 cm <sup>2</sup>	
	2004	1 dpm dose	detectable β	2004	1 dpm dose	detectable β	2004	1 dpm dose	detectable β	2004	1 dpm dose	detectable β	2004	1 dpm dose	detectable β	2004	1 dpm dose	
Nuclide	nf	Times nf	2004	nf	Times nf	2004	nf	Times nf	2004	nf	Times nf	2004	nf	Times nf	2004	nf	dose factor	
H-3	< 3.936E-03	1.319E-07	7.02E-03	< 2.169E-02	7.269E-07	2.88E-02	< 5.168E-03	1.732E-07	3.29E-03	< 4.438E-03	1.487E-07	2.88E-03	3.351E-05					
C-14	< 3.618E-03	6.525E-08	3.48E-03	< 1.058E-02	1.908E-07	7.56E-03	< 3.978E-02	7.174E-07	1.36E-02	< 2.851E-02	5.141E-07	9.95E-03	1.803E-05					
Mn-54	< 1.579E-04	3.321E-10	1.77E-05	< 9.359E-04	1.969E-09	7.80E-05	<b>3.607E-04</b>	7.587E-10	1.44E-05	<b>4.206E-05</b>	8.848E-11	1.71E-06	2.104E-06					
Fe-55	<b>2.348E-02</b>	1.372E-08	7.31E-04	<b>5.639E-02</b>	3.295E-08	1.31E-03	<b>1.015E-03</b>	5.929E-10	1.13E-05	<b>2.553E-03</b>	1.492E-09	2.89E-05	5.843E-07					
Co-57	< 3.182E-04	8.073E-11	4.30E-06	< 1.881E-03	4.772E-10	1.89E-05	< 3.853E-04	9.774E-11	1.86E-06	< 4.736E-04	1.202E-10	2.33E-06	2.537E-07					
Co-58	< 5.662E-08	4.578E-14	2.44E-09	< 3.615E-07	2.923E-13	1.16E-08	< 4.889E-08	3.953E-14	7.52E-10	< 6.306E-08	5.099E-14	9.87E-10	8.086E-07					
Ni-59	< 6.317E-03	7.636E-11	4.07E-06	< 4.415E-03	5.337E-11	2.11E-06	< 4.305E-04	5.204E-12	9.90E-08	< 5.810E-04	7.023E-12	1.36E-07	1.209E-08					
Co-60	<b>9.653E-02</b>	6.086E-07	3.24E-02	<b>2.071E-01</b>	1.306E-06	5.17E-02	<b>5.186E-01</b>	3.270E-06	6.22E-02	<b>5.516E-01</b>	3.478E-06	6.73E-02	6.305E-06					
Ni-63	<b>6.183E-01</b>	6.908E-08	3.68E-03	<b>4.322E-01</b>	4.828E-08	1.91E-03	<b>4.215E-02</b>	4.708E-09	8.96E-05	<b>5.687E-02</b>	6.354E-09	1.23E-04	1.117E-07					
Zn-65	< 2.096E-04	2.216E-09	1.18E-04	< 1.271E-03	1.344E-08	5.32E-04	< 3.116E-04	3.295E-09	6.27E-05	< 4.043E-04	4.276E-09	8.27E-05	1.058E-05					
Sr-90	< 2.305E-03	1.455E-07	7.75E-03	<b>1.651E-02</b>	1.042E-06	4.13E-02	<b>3.599E-03</b>	2.271E-07	4.32E-03	<b>3.117E-03</b>	1.967E-07	3.81E-03	6.310E-05					
Nb-94	< 1.065E-03	1.782E-09	9.49E-05	< 7.745E-03	1.296E-08	5.14E-04	< 1.990E-03	3.331E-09	6.33E-05	< 2.535E-03	4.243E-09	8.21E-05	1.674E-06					
Tc-99	< 4.053E-05	1.303E-08	6.94E-04	< 3.150E-05	1.013E-08	4.01E-04	< 6.755E-05	2.172E-08	4.13E-04	< 6.028E-05	1.939E-08	3.75E-04	3.216E-04					
Ru-106	< 1.619E-03	1.993E-08	1.06E-03	< 8.987E-03	1.107E-07	4.38E-03	< 2.258E-03	2.781E-08	5.29E-04	< 2.832E-03	3.487E-08	6.75E-04	1.232E-05					
Ag-110m	< 1.256E-03	4.333E-09	2.31E-04	< 6.093E-03	2.102E-08	8.33E-04	< 1.708E-03	5.890E-09	1.12E-04	< 2.147E-03	7.404E-09	1.43E-04	3.449E-06					
Sb-125	< 2.264E-03	4.544E-09	2.42E-04	< 8.713E-03	1.749E-08	6.93E-04	<b>2.827E-03</b>	5.674E-09	1.08E-04	< 3.093E-03	6.208E-09	1.20E-04	2.007E-06					
I-129	< 8.091E-08	5.250E-10	2.80E-05	< 6.277E-08	4.073E-10	1.61E-05	< 1.346E-07	8.733E-10	1.66E-05	< 1.201E-07	7.791E-10	1.51E-05	6.489E-03					
Cs-134	<b>4.255E-03</b>	1.014E-07	5.40E-03	< 3.114E-03	7.424E-08	2.94E-03	<b>1.951E-03</b>	4.651E-08	8.85E-04	<b>1.361E-03</b>	3.246E-08	6.28E-04	2.384E-05					
Cs-137	<b>2.222E-01</b>	3.567E-06	1.90E-01	<b>1.725E-01</b>	2.769E-06	1.10E-01	<b>3.701E-01</b>	5.942E-06	1.13E-01	<b>3.303E-01</b>	5.303E-06	1.03E-01	1.605E-05					
Ce-144	< 3.600E-04	3.731E-10	1.99E-05	< 2.155E-03	2.233E-09	8.85E-05	< 4.181E-04	4.333E-10	8.24E-06	< 5.199E-04	5.389E-10	1.04E-05	1.036E-06					
Pm-147	< 7.735E-04	1.569E-09	8.36E-05	< 1.766E-03	3.581E-09	1.42E-04	< 1.674E-04	3.395E-10	6.46E-06	< 1.755E-04	3.560E-10	6.89E-06	2.028E-06					
Eu-154	< 2.060E-03	1.584E-09	8.44E-05	< 9.923E-03	7.631E-09	3.02E-04	< 3.405E-03	2.619E-09	4.98E-05	< 4.419E-03	3.398E-09	6.58E-05	7.690E-07					
Eu-155	< 1.245E-03	1.224E-10	6.52E-06	< 8.223E-03	8.081E-10	3.20E-05	< 1.787E-03	1.756E-10	3.34E-06	< 2.288E-03	2.249E-10	4.35E-06	9.828E-08					
Pu-238	< 6.927E-05	9.641E-09	5.14E-04	<b>2.898E-04</b>	4.033E-08	1.60E-03	<b>3.849E-05</b>	5.357E-09	1.02E-04	<b>3.581E-05</b>	4.984E-09	9.64E-05	1.392E-04					
Pu-239	< 2.271E-05	3.497E-09	1.86E-04	<b>2.607E-04</b>	4.015E-08	1.59E-03	<b>1.411E-05</b>	2.172E-09	4.13E-05	<b>2.565E-05</b>	3.949E-09	7.64E-05	1.540E-04					
Pu-240	< 2.270E-05	3.496E-09	1.86E-04	<b>2.607E-04</b>	4.014E-08	1.59E-03	<b>1.411E-05</b>	2.172E-09	4.13E-05	<b>2.564E-05</b>	3.948E-09	7.64E-05	1.540E-04					
Pu-241	< 6.730E-03	2.009E-08	1.07E-03	<b>1.536E-02</b>	4.584E-08	1.82E-03	<b>1.457E-03</b>	4.348E-09	8.27E-05	<b>1.527E-03</b>	4.557E-09	8.82E-05	2.985E-06					
Am-241	< 6.356E-04	2.961E-08	1.58E-03	<b>1.557E-03</b>	7.252E-08	2.87E-03	<b>1.681E-05</b>	7.832E-10	1.49E-05	< 2.242E-06	1.045E-10	2.02E-06	4.658E-05					
Cm-242	< 3.505E-06	2.454E-12	1.31E-07	< 9.076E-07	6.356E-13	2.52E-08	< 4.845E-09	3.393E-15	6.45E-11	< 4.715E-09	3.302E-15	6.39E-11	7.002E-07					
Cm-243	< 1.086E-04	1.663E-09	8.86E-05	< 6.707E-05	1.027E-09	4.07E-05	<b>1.208E-06</b>	1.850E-11	3.52E-07	< 2.123E-07	3.251E-12	6.29E-08	1.531E-05					
Cm-244	< 1.041E-04	1.282E-09	6.83E-05	< 6.425E-05	7.914E-10	3.14E-05	<b>1.158E-06</b>	1.426E-11	2.71E-07	< 2.034E-07	2.505E-12	4.85E-08	1.232E-05					
sum	1.000E+00		<b>2.57E-01</b>	1.000E+00	<b>6.63E-06</b>	<b>2.63E-01</b>	1.000E+00	<b>1.05E-05</b>	<b>1.99E-01</b>	1.000E+00	<b>9.78E-06</b>	<b>1.89E-01</b>						
obs. β fraction	3.379E-01			4.544E-01			9.464E-01			9.302E-01								

**Table 6**  
**Nuclide Fraction and Dose After Removal of MDA Nuclides**  
**O/A Trench and PAB Pipe Tunnel**  
 (Table 6 Page 1 of 2)

Column # ==> 1	2	3	4	5	6	7	8	9	10
7/30/02	Pipe Tunnel	Pipe Tunnel		Dose For		Pipe Tunnel	Pipe Tunnel		Dose For
	CA9900	CA9900		1.80E+04		CA9900	CA9900		1.80E+04
	13-C002-A	13-C002-A		dpm/100 cm2		13-C003-A	13-C003-A		dpm/100 cm2
	2004	2004	1 dpm dose	detectable β		2004	2004	1 dpm dose	detectable β
Nuclide	initial nf	normalized nf	Times nf	2004		initial nf	normalized nf	Times nf	2004
Mn-54	< 1.579E-04	1.616E-04	3.40E-10	1.83E-05	<	9.359E-04	1.023E-03	2.151E-09	8.689E-05
Fe-55	<b>2.348E-02</b>	<b>2.403E-02</b>	1.40E-08	7.54E-04		<b>5.639E-02</b>	6.162E-02	3.600E-08	1.454E-03
Co-60	<b>9.653E-02</b>	<b>9.878E-02</b>	6.23E-07	3.34E-02		<b>2.071E-01</b>	2.262E-01	1.426E-06	5.762E-02
Ni-63	<b>6.183E-01</b>	<b>6.328E-01</b>	7.07E-08	3.80E-03		<b>4.322E-01</b>	4.722E-01	5.275E-08	2.131E-03
Sr-90	< 2.305E-03	2.359E-03	1.49E-07	7.99E-03		<b>1.651E-02</b>	1.804E-02	1.138E-06	4.597E-02
Sb-125	< 2.264E-03	2.317E-03	4.65E-09	2.50E-04	<	8.713E-03	9.520E-03	1.911E-08	7.718E-04
Cs-134	<b>4.255E-03</b>	<b>4.354E-03</b>	1.04E-07	5.58E-03	<	3.114E-03	3.402E-03	8.112E-08	3.276E-03
Cs-137	<b>2.222E-01</b>	<b>2.274E-01</b>	3.65E-06	1.96E-01		<b>1.725E-01</b>	1.884E-01	3.025E-06	1.222E-01
Pu-238	< 6.927E-05	7.088E-05	9.87E-09	5.30E-04		<b>2.898E-04</b>	3.166E-04	4.407E-08	1.780E-03
Pu-239	< 2.271E-05	2.324E-05	3.58E-09	1.92E-04		<b>2.607E-04</b>	2.849E-04	4.386E-08	1.772E-03
Pu-240	< 2.270E-05	2.323E-05	3.58E-09	1.92E-04		<b>2.607E-04</b>	2.848E-04	<b>4.385E-08</b>	1.771E-03
Pu-241	< 6.730E-03	6.888E-03	2.06E-08	1.10E-03		<b>1.536E-02</b>	1.678E-02	5.009E-08	2.023E-03
Am-241	< 6.356E-04	6.505E-04	3.03E-08	1.63E-03		<b>1.557E-03</b>	1.701E-03	7.924E-08	3.201E-03
Cm-243	< 1.086E-04	1.112E-04	1.70E-09	9.14E-05	<	6.707E-05	7.328E-05	1.122E-09	4.531E-05
Cm-244	< 1.041E-04	1.065E-04	1.31E-09	7.05E-05	<	6.425E-05	7.020E-05	8.647E-10	3.493E-05
<b>sum</b>	9.772E-01	1.000E+00	4.686E-06	2.556E-01		9.152E-01	1.000E+00	6.061E-06	2.517E-01
obs. b fraction	3.28E-01	3.35E-01				4.08E-01	4.46E-01		

**Table 6**  
**Nuclide Fractions and Dose After Removal of MDA Nuclides**  
**O/A Trench and PAB Pipe Tunnel**  
 (Table 6 page 2 of 2)

Column # ==>	11	12	13	14	15	16	17	18	19	20
		O/A Trench	O/A Trench		Dose For		O/A Trench	O/A Trench		Dose For
		CA9900	CA9900		1.80E+04		CA9900	CA9900		1.80E+04
		12-C001-A	12-C001-A		dpm/100 cm2		12-C002-A	12-C002-A		dpm/100 cm2
		2004	2004	1 dpm dose	detectable β		2004	2004	1 dpm dose	detectable β
Nuclide		initial nf	normalized nf	Times nf	2004		initial nf	normalized nf	Times nf	2004
Mn-54		3.607E-04	3.828E-04	8.053E-10	1.522E-05		4.206E-05	4.425E-05	9.308E-11	1.790E-06
Fe-55		1.015E-03	1.077E-03	6.293E-10	1.190E-05		2.553E-03	2.685E-03	1.569E-09	3.018E-05
Co-60		5.186E-01	5.504E-01	3.470E-06	6.561E-02		5.516E-01	5.803E-01	3.659E-06	7.038E-02
Ni-63		4.215E-02	4.473E-02	4.998E-09	9.448E-05		5.687E-02	5.982E-02	6.684E-09	1.286E-04
Sr-90		3.599E-03	3.820E-03	2.411E-07	4.557E-03		3.117E-03	3.279E-03	2.069E-07	3.980E-03
Sb-125		2.827E-03	3.000E-03	6.022E-09	1.138E-04	<	3.093E-03	3.253E-03	6.530E-09	1.256E-04
Cs-134		1.951E-03	2.071E-03	4.937E-08	9.333E-04		1.361E-03	1.432E-03	3.415E-08	6.568E-04
Cs-137		3.701E-01	3.928E-01	6.307E-06	1.192E-01		3.303E-01	3.475E-01	5.579E-06	1.073E-01
Pu-238		3.849E-05	4.085E-05	5.686E-09	1.075E-04		3.581E-05	3.767E-05	5.243E-09	1.008E-04
Pu-239		1.411E-05	1.498E-05	2.306E-09	4.359E-05		2.565E-05	2.698E-05	4.154E-09	7.991E-05
Pu-240		1.411E-05	1.497E-05	2.305E-09	4.358E-05		2.564E-05	2.697E-05	4.153E-09	7.989E-05
Pu-241		1.457E-03	1.546E-03	4.615E-09	8.724E-05		1.527E-03	1.606E-03	4.794E-09	9.222E-05
Am-241		1.681E-05	1.785E-05	8.313E-10	1.571E-05	<	2.242E-06	2.359E-06	1.099E-10	2.114E-06
Cm-243		1.208E-06	1.283E-06	1.963E-11	3.712E-07	<	2.123E-07	2.234E-07	3.419E-12	6.577E-08
Cm-244		1.158E-06	1.229E-06	1.513E-11	2.861E-07	<	2.034E-07	2.140E-07	2.636E-12	5.070E-08
sum		9.421E-01	1.000E+00	1.010E-05	1.909E-01		9.506E-01	1.000E+00	9.512E-06	1.830E-01
obs. b fraction		8.97E-01	9.52E-01				8.90E-01	9.36E-01		

**Table 7**  
**Mean and Standard Deviation of Dose**  
**For TRU Affected Cores**  
**Using the Average of the Fractions and Individual Core Method**

Column # ==>	2	3	4	5	6	7	8	9
	<b>4 Cores</b>	<b>Dose Results (in mrem) for Average of the Fractions (1.0 dpm)</b>						
<b>Nuclide</b>	<b>Mean nf</b>	<b>13-C002-A</b>	<b>13-C003-A</b>	<b>12-C001-A</b>	<b>12-C002-A</b>	<b>mean*</b>	<b>stdev mean</b>	<b>(stdev Mean)<sup>2</sup></b>
Mn-54	4.028E-04	3.40E-10	2.151E-09	8.053E-10	9.308E-11	2.286E-05	1.238E-05	1.533E-10
Fe-55	2.235E-02	1.40E-08	3.600E-08	6.293E-10	1.569E-09	3.523E-04	2.222E-04	4.935E-08
Co-60	3.639E-01	6.23E-07	1.426E-06	3.470E-06	3.659E-06	6.190E-02	2.030E-02	4.120E-04
Ni-63	3.024E-01	7.07E-08	5.275E-08	4.998E-09	6.684E-09	9.114E-04	4.464E-04	1.993E-07
Sr-90	6.874E-03	1.49E-07	1.138E-06	2.411E-07	2.069E-07	1.170E-02	6.355E-03	4.039E-05
Sb-125	4.523E-03	4.65E-09	1.911E-08	6.022E-09	6.530E-09	2.449E-04	9.084E-05	8.252E-09
Cs-134	2.815E-03	1.04E-07	8.112E-08	4.937E-08	3.415E-08	1.811E-03	4.226E-04	1.786E-07
Cs-137	2.890E-01	3.65E-06	3.025E-06	6.307E-06	5.579E-06	1.252E-01	2.097E-02	4.395E-04
Pu-238	1.165E-04	9.87E-09	4.407E-08	5.686E-09	5.243E-09	4.375E-04	2.520E-04	6.352E-08
Pu-239	8.752E-05	3.58E-09	4.386E-08	2.306E-09	4.154E-09	3.636E-04	2.735E-04	7.479E-08
Pu-240	8.750E-05	3.58E-09	4.385E-08	2.305E-09	4.153E-09	3.635E-04	2.734E-04	7.476E-08
Pu-241	6.705E-03	2.06E-08	5.009E-08	4.615E-09	4.794E-09	5.399E-04	2.886E-04	8.330E-08
Am-241	5.929E-04	3.03E-08	7.924E-08	8.313E-10	1.099E-10	7.452E-04	5.015E-04	2.515E-07
Cm-243	4.649E-05	1.70E-09	1.122E-09	1.963E-11	3.419E-12	1.920E-05	1.137E-05	1.292E-10
Cm-244	4.454E-05	1.31E-09	8.647E-10	1.513E-11	2.636E-12	1.480E-05	8.760E-06	7.674E-11

\* 1 dpm average value times 18,000/0.6672 (obs. average beta fraction) = 2.698E+04

<b>Mean</b>
2.046E-01
<b>Standard Deviation Of the Mean</b>
2.988E-02

**Core Dose Results From Individual Cores 18,000 dpm/100 cm<sup>2</sup> Observable Beta**

<b>Nuclide</b>	<b>13-C002-A</b>	<b>13-C003-A</b>	<b>12-C001-A</b>	<b>12-C002-A</b>
Mn-54	1.83E-05	8.689E-05	1.522E-05	1.790E-06
Fe-55	7.54E-04	1.454E-03	1.190E-05	3.018E-05
Co-60	3.34E-02	5.762E-02	6.561E-02	7.038E-02
Ni-63	3.80E-03	2.131E-03	9.448E-05	1.286E-04
Sr-90	7.99E-03	4.597E-02	4.557E-03	3.980E-03
Sb-125	2.50E-04	7.718E-04	1.138E-04	1.256E-04
Cs-134	5.58E-03	3.276E-03	9.333E-04	6.568E-04
Cs-137	1.96E-01	1.222E-01	1.192E-01	1.073E-01
Pu-238	5.30E-04	1.780E-03	1.075E-04	1.008E-04
Pu-239	1.92E-04	1.772E-03	4.359E-05	7.991E-05
Pu-240	1.92E-04	1.771E-03	4.358E-05	7.989E-05
Pu-241	1.10E-03	2.023E-03	8.724E-05	9.222E-05
Am-241	1.63E-03	3.201E-03	1.571E-05	2.114E-06
Cm-243	9.14E-05	4.531E-05	3.712E-07	6.577E-08
Cm-244	7.05E-05	3.493E-05	2.861E-07	5.070E-08
<b>dose sum</b>	2.517E-01	2.441E-01	1.909E-01	1.830E-01

**Individual Core (4) Propagation of Error**

<b>Mean</b>
2.17E-01
<b>Standard Deviation of the Mean</b>
1.77E-02

**ATTACHMENT 2G**

**Supplemental Information Regarding Concrete Core Data Use**



### Supplemental Information Regarding Concrete Core Data Use

To characterize contaminated concrete surfaces, there were three sets of concrete cores obtained and analyzed. The resulting data was used to establish the appropriate nuclide fractions and support the dose assessment in Section 6. Each core set was taken for different reasons and was analyzed by methods appropriate to each set's purpose. The following discussion summarizes the purpose of each set and key elements of the analysis for each.

#### A. Initial Set of Concrete Cores (Initial Site Characterization)

The first set of cores were collected during initial site characterization by GTS Duratek and were used to represent typical concrete nuclide data. Seven of these cores with the highest total activity were selected for off-site analysis to determine the amount of HTD nuclides present. (Using the highest activity cores offered the best chance of detection for low activity HTD nuclides.) The HTDs were determined using radiochemical analytical techniques; gamma emitting nuclides were determined by gamma spectroscopy with the cores counted 21 inches above the detector to approximate a point source. The results from these cores formed the basis for the establishment of the contaminated concrete surface nuclide fraction for the majority of basement concrete surfaces (i.e., the "balance of plant" concrete surfaces). Certain subsequent core samples and analyses would lead to establishing a separate, unique nuclide fraction for limited areas warranting such treatment. This is discussed below. See Section 2.5.3a and Attachment 2F for additional detail.

#### B. Second Set of Concrete Cores

Forty three (43) additional cores were collected during continuing site characterization. This data was used primarily for establishing  $E_t$  for contaminated concrete. The number of cores obtained was established so that each building or plant area would have several cores included in the data analysis with the goal that the sample population, as a whole, would more accurately represent the nuclide ratios for concrete surfaces. These 43 core samples were processed for the  $E_t$  determination by initially gross counting the cores, followed by gamma spectroscopy analysis. The cores were counted initially onsite; six cores were later recounted at an offsite vendor's laboratory (DES<sup>1</sup>). The onsite HPGe detectors had been calibrated using a concrete standard of uniform activity. The samples were counted at DES using a similar geometry, and the results showed good agreement. In order to determine total activity for the  $E_t$  calculation, six of the cores were dissolved, and the dissolved material was again counted using the geometry specific to the analytical technique. The counting results for the dissolved cores showed that the activity was mostly on the surface of the concrete. (Later evaluation of the data using Microshield modeling verified that the Co-60 activity was located on the surface of the concrete and had a correction factor of approximately 0.5 while the Cs-137 activity was as deep as 1 mm in the core

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<sup>1</sup> Duke Engineering and Services Environmental Laboratory, now referred to as "Framatome ANP DE&S Environmental Laboratory."

and had a correction factor of 0.73.) An average correction factor was determined to convert the activity from a surface count to the total activity in the core. The value of the correction factor was determined to be 0.68 from the DES data, as compared to 0.67 based on the onsite data.

#### C. Third Set of Concrete Cores

Upon reviewing some of the original GTS data, a question remained concerning the possible presence of TRUs on concrete surfaces. A specific area of concern was the containment outer annulus trench. A decision was made to obtain cores on either side of an original trench sample to confirm or disprove the presence of TRUs. At the same time, additional cores were obtained to replace those destroyed by sample analysis. Three additional cores were collected from within the loops of containment, and three additional samples were collected in the PAB. Thus, the third set of cores totaled 8.

This set of core samples was analyzed by gross counting, gamma spectroscopy, and offsite analysis for HTD nuclides. This data formed the basis for the development of the alternate concrete nuclide fraction for trenches, pipe tunnel and other unique ("special") areas, as discussed in Section 2.5.3.a and Attachment 2F. Background information related to the development of this nuclide fraction was described in a special report from the Technical Issue Resolution Process (TIRP). The report addressed a number of concerns related to the presence of TRUs in certain plant locations. (See Section 2.7, References.)

#### D. Core Data Adjustments

The nuclide fraction given in Table 2-7 of the LTP was derived from the data provided by the seven original cores. Four of the additional eight cores were confirmed to be included in the "balance of plant" concrete surfaces, as represented by the initial seven cores. The remaining four cores in the "third" set supported the establishment of a nuclide fraction for the "special areas" involving the various trenches and areas which were confirmed (or expected) to contain TRUs. (See Table 2-8.)

The data reported in Table 2C-2 of the LTP is a combination of the 43 additional cores plus the eight cores from the "third" data set. The core activities were reported with no geometry correction in Attachment 8 of EC 010-01. The core activities were then geometry corrected for use in the  $E_t$  calculation (Attachment 5 of EC 010-01), and the geometry corrected data were presented in the LTP Table 2C-2 except for the activated concrete samples (Sample # 3-1A, 3-2A, and 3-3A) which were used only for activated concrete characterization.

#### E. Net Count Rate

The net count rate data were determined by counting the cores in a low background area following their removal from the building floors. The count rate values were adjusted for ambient area background, and the "net cpm" was reported in Table 2C-2.

## **ATTACHMENT 2H**

### **Forebay and Diffuser Characterization Discussion**

## Forebay and Diffuser Characterization Discussion

### 1. Physical Description of the Forebay/ and Diffuser

The principal forebay structure consists of the forebay basin which is approximately 400 feet in length with a granite floor, rock and soil walls (or dikes), and concrete structures at both ends. The forebay is aligned generally in a north-south direction such that the concrete structures are located at the north and south ends with the dikes forming the east and west sides. The seal pit is at the northern end, and the diffuser intake structure is located at the southern end. During operations, plant cooling water discharged into the seal pit and then flowed over a concrete seal pit weir wall, into the forebay basin. With the cooling water system permanently secured, the flow in and out of the forebay is influenced primarily by tidal fluctuations. The forebay connects to the Back River through the diffuser piping. The intake to the diffuser piping is at the southern end of the forebay. See Figure 2H-1.

The forebay dikes were designed and constructed to achieve structural stability and minimize leakage by the choice, dimensions, and placement of pervious, impervious, and protective materials. On the interior sides of the dikes (that is, on the forebay side), the exterior layer consists of two feet (or greater) of large protective "coarse rock" (rip-rap). Beneath the rip-rap is about two feet of cobble stones<sup>1</sup>. Underneath the cobble stone layer is about two feet of gravel ("pervious fill"). Finally, beneath the gravel layer is impervious fill material. The dike walls are inclined at a slope of approximately 1.75:1 (that is, 1.75 feet horizontal run for every 1 foot of vertical drop) which results in a slope angle of about 30 degrees from the horizontal plane. See Figure 2H-2.

The diffuser system consists of large fiberglass pipes which connect the forebay basin to the diffuser discharge, submerged in the Back River. At the forebay's southern end, the diffuser supply piping is nine feet in diameter. Downstream sections continually decrease to a diameter of approximately 5 feet with nozzles of 18 inches in diameter, spaced in the diffuser discharge piping. The diffuser at its discharge is submerged at a depth of over 40 feet below MSL.

The characterization of the forebay identified the following principal contaminated media:

- Floors of the forebay and seal pit. This includes other concrete surfaces, such as the seal pit weir wall. (This weir wall will be demolished down to 3' below grade.)
- Rip-rap, contaminated on the rock surfaces.
- Marine sediment (primary organic material), deposited on floors of forebay basin and seal pit and around the rip-rap.

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<sup>1</sup> This 2 foot thick layer is specified to be "6 inch minus," i.e., containing material no greater than 6" in diameter. In Figure 2H-2, this layer is referred to as "fine rock cover."

- Dike "soil", that is, any material interior to dike below the rip-rap covering, including cobble, gravel, and other soil materials, as well as sediment deposited around the cobble.<sup>2</sup>

Remediation plans call for the removal of a majority of the accessible marine sediment in the forebay. Once the sediment remediation is accomplished, the principal contamination source term is expected to be the dike "soil" beneath the rip-rap, based on the assessment of activity levels in the various media. As noted above, the other contaminated media that would remain are the rip-rap (with surface contamination) and whatever sediment and other surface contamination that may remain on forebay/seal rock and concrete floors. See Section 6.6.9 for the discussion of the dose assessment and contribution of each of these remaining contaminated media.

The characterization of the diffuser identified two principal contaminated media, namely:

- Marine sediment that has been re-deposited internal to the diffuser piping by tidal action (following the permanent shutdown of the plant's cooling water system).
- Contaminated internal surfaces of the diffuser fiberglass piping.

Seaweed is also considered in the diffuser dose assessment; therefore, characterization information is discussed in this attachment. See Section 6.6.9 for the dose assessment related to diffuser source terms.

## **2. Forebay (and Seal Pit): Contaminated Media Characterization**

As part of the site's initial characterization (by GTS-Duratek), several forebay samples were obtained and analyzed. Subsequent to that sampling (late 2000), an additional set of 15 sediment samples were obtained by Maine Yankee (see EC 004-01), composited, and analyzed for HTDs. The LTP Rev. 1 nuclide fraction for forebay sediment (Section 2.5.3.e) was established based on this sampling and analysis (decay corrected to 1/1/2004). No TRU's were detected in this 2000 composite sample.<sup>3</sup> This nuclide fraction is presented in Table 2H-1 below.

In 2001, an expanded sampling program was developed and implemented to support further characterization and remediation planning. This effort involved more extensive sampling of the forebay and principal forebay features to gain insight regarding spatial variations in activity, sediment deposition, and the activity depth profile interior to the forebay dikes. At the same time, remediation planning was involved in a number of studies and field tests to determine the optimum remediation techniques. These studies and tests also included the evaluation of material handling equipment required to address the somewhat unique challenges of the forebay, given the marine environment, variety of material sizes (from rip-rap to glacial till), and relatively steep slopes (of the forebay dikes).

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<sup>2</sup> An additional, extensive dike coring program was completed in the third quarter of 2002 to better define remediation requirements of the dike soil beneath the rip-rap. See Section 2.4 of this attachment for additional detail.

<sup>3</sup> The composite forebay sediment sample was analyzed for a standard suite of TRU nuclides. See Attachment 1 of EC-041-01 for identification of specific nuclides.

<b>Table 2H-1. Forebay Sediment Nuclide Fraction (Decay corrected to 1/1/2004)</b>	
<b>Nuclide</b>	<b>Fraction</b>
Co-60*	0.567
Cs-137*	0.030
Sb-125	0.005
Fe-55	0.165
Ni-63	0.233

\* The resulting Co-60/Cs-137 from this data is 18.9.

The 2001 sampling program included the following principal tasks:

- Sampling of organic sediment around the rip-rap on both the east and west dikes;
- Sampling of sediment material accumulated on exposed rock surfaces in the vicinity of the weir wall at the northern end of the forebay;
- Sampling of underwater sediment on forebay basin floor and on the bottom (floor) of the seal pit.
- Subsequent, depth profile sampling into the dike material or "soil."

In addition, as part of work directly related to remediation planning, rip-rap surface samples were analyzed for material composition and activity concentration.

The results of the characterization efforts are summarized below. See EC-041-01 for additional detail on sample locations, individual sample results, analysis of results, and use in the dose assessment

### **2.1 Dike Spatial Activity Distribution**

A total of forty (40) sediment samples were taken to provide information of spatial variance of activity in the sediment deposited in the tidal zone around the rip-rap on the forebay dike interior surfaces. Twenty (20) samples were obtained on each dike, i.e., ten samples along the high tide line and ten (10) samples along the low tide line. See Table 2H-2.

<b>Table 2H-2. Sediment Around Rip-Rap at Forebay High &amp; Low Tide Lines</b>										
<b>Sample Location</b>	<b>Co-60 (pCi/g)</b>					<b>Cs-137 (pCi/g)</b>				<b>Co/Cs Ratio</b>
	<b>Max</b>	<b>Min</b>	<b>Avg</b>	<b>Std Dev</b>		<b>Max</b>	<b>Min</b>	<b>Avg</b>	<b>Std Dev</b>	
High Tide Line (East & West Combined)	92.6	1.8	16.9	21.8		6.5	0.2	1.2	1.4	14.6
Low Tide Line (East & West Combined)	62.7	4.5	22.5	15.2		1.9	0.3	1.0	0.5	22.0
High & Low Tide Line Combined	92.6	1.8	19.7	18.8		6.5	0.2	1.1	1.0	18.0

As shown in Table 2H-2, the sediment samples collected at the low tide line reported a higher Co-60 average than those collected at the high tide line. (The Cs-137 values for both high and low tide were relatively low by comparison.)

The two tidal area sediment samples with the highest reported Co-60 activity were 63.6 and 92.6 pCi/g, collected on the northern portion of the west dike at high tide. See Figure 2H-1. Because of the high concentrations, these particular locations were chosen for additional sampling to explore the activity profile interior to the dikes. The results from this effort are described below in Section 2.4 (of this attachment).

While these levels in the tidal area sediment are high relative to remediation levels (i.e., the DCGL proposed in Section 6 dose modeling), the profile sampling confirmed at these locations that a large portion of the contamination is near the dike soil surface, that is, the material immediately beneath the rip-rap covering. Later, more extensive sampling of the dike soil beneath the rip-rap demonstrated that the contaminated material has not penetrated beneath the rip-rap to any significant extent. (See Section 2.4 for additional discussion.) Since the contaminated sediment is generally accessible, loose, and concentrated near the surface, measures under consideration for sediment remediation around the rip-rap and on the basin/seal pit floors are expected to be quite effective.

Dose modeling addresses each of the contaminated media (described in Section 1 of this attachment) including separate treatment of contaminated floors and the interior dike soil. See Section 6.6.9.

## 2.2 Exposed Sediment Material (in vicinity of weir wall)

Nine (9) samples were collected from material (sediment, soil, and other material) available on the exposed rock, i.e., having no rip-rap layer, at the northern end of the forebay/seal pit structure in the area of the seal pit weir. Most of these samples were



obtained on the west side to provide appropriate coverage of the area in the path of the emergency spillway.<sup>4</sup>

This set of exposed sediment samples exhibited the highest activity concentrations of all samples obtained in this particular sampling campaign of Spring 2001. See Table 2H-3 a summary of these results.

<b>Table 2H-3. Sample Results: Sediment from Exposed Rock Surfaces and Underwater Sediment</b>									
	<b>Co-60 (pCi/g)</b>					<b>Cs-137 (pCi/g)</b>			
<b>Sample Location</b>	<b>Max</b>	<b>Min</b>	<b>Avg</b>	<b>Std Dev</b>		<b>Max</b>	<b>Min</b>	<b>Avg</b>	<b>Std Dev</b>
Exposed Sediment Material	445.0	0.2	65.9	148.3		23.8	0.3	3.3	7.7
Underwater Sediment (Forebay and Seal Pit)	62.7	5.5	19.0	16.4		7.0	0.2	1.9	2.1

- a. The average activities of the exposed sediment material samples were: 65.9 pCi/g Co-60 and 3.3 pCi/g Cs-137. The maximum reported activity, 445 pCi/g Co-60 and 23.8 pCi/g Cs-17, was associated with a sample collected on the western side, near the weir. See Figure 2H-1 for approximate location. The second highest sample, collected from an area immediately adjacent to the above sample (on the exposed rock), reported 130 pCi/g Co-60 and 3.3 pCi/g Cs-137.
- b. Not only did these samples report the maximum activity for any location sampled in this campaign, but also they were particularly high relative to the other exposed sediment samples. For sample the Co-60 concentrations ranged from 0.2 to 10.7 pCi/g and Cs-137 from 0.3 to 0.5 pCi/g for the other seven (7) exposed sediment samples.
- c. The average exposed sediment sample activities (excluding the two highest samples) were 2.64 pCi/g Co-60 and 0.4 pCi/g Cs-137. The average activities for all nine (9) exposed sediment samples were 65.9 pCi/g and 3.3 pCi/g Cs-137. The average Co/Cs ratio was 19.8 (using the data from all nine samples).
- d. The two highest exposed sediment samples were sent to an outside laboratory for

<sup>4</sup> From 1972 until late 1974, cooling water discharge passed over the weir and directly into Bailey Cove. During that time period, the flow path included portions of exposed rock now part of the western dike (at the northern end). Construction of the west dike and diffuser system was completed in 1975. The western exposed rock then became part of an emergency spillway to provide a pathway in the event the diffuser system was not operating properly.

HTD analyses. The nuclide fraction results from these HTD analyses were comparable to the 2000 composite sediment HTD results with the exception that the exposed sediment sample analysis identified the presence of TRU nuclides in very low concentrations. The MDC values of the 2000 composite sediment sample analyses would have been low enough to detect the TRU nuclides had they been present at the levels found in the later exposed sediment samples.<sup>5</sup> The original and later HTD data sets were compared and evaluated. The TRU nuclides, reported in the exposed sediment samples, were determined to represent less than 1% of the total dose associated with forebay media and were, therefore, eliminated from the nuclide fraction. Overall, it was determined that the original nuclide fraction for sediment (reported in LTP Rev. 1) was conservative due to the its higher proportion of dose-significant gamma emitters (i.e., Co-60, Cs-137, and Sb-125). The original nuclide fraction was, therefore, used in the dose assessment.

- e. Lastly, as mentioned above, the exposed rock area, by its nature, contains only a small amount of material. While two of the exposed sediment samples reported very high activity, it is expected that remediation measures in this area will be quite effective because the total volume of material on these exposed rock surfaces is relatively small and because the contamination is loose and accessible.

### 2.3 Underwater Forebay (and Seal Pit) Sediment

Thirteen (13) sediment samples were taken from underwater areas in the forebay and seal pit. Activity levels for underwater sediment were comparable to that of sediment deposited on the dikes around the rip-rap, presented in Table 2H-2 above. The overall average activities (combining forebay and seal pit samples) are 19.0 pCi/g Co-60 and 1.9 pCi/g Cs-137. Table 2H-3 summarizes the results from this sampling. Since this sediment is accessible (by diving operation) and can be vacuumed by any number of proven techniques, remediation measures for this contaminated media are expected to be quite effective.

### 2.4 Dike "Soil" Activity Profile

As discussed in Section 2.1 above, depth profile samples were taken at the two locations exhibiting the highest activity levels in the rip-rap tidal zone. This sampling was undertaken to gain further insight regarding the penetration of activity into the dike interior (and to support remediation planning). See Figure 2H-1 for the surface (starting) location for these profile samples.

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<sup>5</sup> See Attachment 1 of EC-041-01 for the listing of MDC values obtained in the subject sediment analyses by Duke Engineering and Services Laboratory, i.e., the "2000 composite" forebay sediment sample and the more recent, higher activity exposed sediment samples (Sample numbers: H059 and H060).

The depth profile samples were taken in 6" intervals down to a depth of 24." The dike soil material for each 6" interval was composited. Both series demonstrated a generally decreasing activity concentration with depth. See Table 2H-4, which provides the average Co-60 and Cs-137 activities values (average of the two profile samples at a given profile location). Overall, this initial data indicated that the majority of the contamination was concentrated near the surface of the dike soil. This initial information on potential dike soil activity, while limited, was used in the forebay dose assessment.

It was recognized that additional sampling of the dike soil was appropriate for remediation planning and to confirm activity level assumptions used in the dose assessment. This sampling effort involved the use of coring into the area beneath the rip-rap (parallel to the slope) by way of inclined drilling from the top of the dike, as well as several vertical corings near the centerline of each dike. This dike coring campaign was completed in the third quarter of 2002.

The dike soil samples taken from both vertical and inclined corings revealed very low levels of contamination, much lower than that assumed in the forebay dose assessment. The sampling program was quite extensive and involved a total of 19 corings (total vertical and inclined), including corings at the approximate locations at which the previous two profile samples (presented in Table 2H-4) were taken. The 19 corings were made down to the bedrock layer beneath the dikes and varied in depth from approximately 12 to 80 feet. Samples were taken by compositing material from approximately each meter of depth. This sampling density resulted in over 270 individual samples, with approximately 210 coming from the inclined corings.

The samples were analyzed by gamma spectroscopy on site (i.e., using a HPGe detector). Most of the 270 dike samples from the later campaign were analyzed to be less than the MDA. The averages of all positively detected Co-60 (six positives) and Cs-137 (38 positives) were 0.071 pCi/g and 0.082 pCi/g, respectively. These levels are much lower than the values used in the forebay dose assessment for dike soil (Section 6.6.9), as well as the surface soil DCGLs for Co-60 and Cs-137. These dike characterization results show that contaminated material has not, in general, penetrated to any significant extent into the dike material beneath the rip-rap. As noted above, the forebay dose assessment was based on the limited results from the two profile samples (shown in Table 2H-4). This later dike coring campaign is considered to be a more complete and representative characterization of dike soil contamination. However, since the values presented in Table 2H-4 are conservatively higher, the dose assessment (for dike soil) will continue to be based on Table 2H-4 and requires no change. Additional discussion on the dike coring results is provided in Maine Yankee's letter to the NRC, dated December 12, 2002 (Reference 2.7.26).

<b>Table 2H-4. Depth Profile Sample Results<sup>6</sup></b> (Average activity values for samples collected at the listing location)			
<b>Location</b>	<b>Co-60 pCi/g</b>	<b>Cs-137 pCi/g</b>	<b>Co/Cs Ratio</b>
"Surface" sediment <sup>7</sup>	78.2	4.6	17.0
6" (Composite) <sup>8</sup>	15.3	0.9	16.7
12" (Composite)	6.7	0.6	11.0
18" (Composite)	2.6	0.3	8.2
24" (Composite)	2.8	0.2	12.0

## 2.5 Rip-Rap Rock, Surface Activity

As part of other remediation planning activities (mentioned above), material samples were obtained from rip-rap rock surfaces. The contamination was noted to adhere to the rip-rap rock surface much like that on diffuser piping surface, i.e., by being incorporated into an organic film. The surface material adhering to the rip-rap (in areas exposed to tidal action) exhibited the same general appearance as that found on the piping coupons retrieved for analysis from the diffuser piping. The surface activity concentrations (on rip-rap and diffuser piping) were also comparable. For these reasons, the rip-rap surface data and the information from the diffuser piping surfaces were used to establish the average rip-rap rock surface activities of 0.1 pCi/g Co-60 and 0.1 pCi/g Cs-137. Table 2H-5 lists the rip-rap surface activities and offers comparison to other media contamination levels.

## 2.6 Forebay/Seal Pit Floors and other Forebay Concrete Surfaces

No contamination data is available for the forebay/seal pit floors (or other forebay concrete surfaces). The largest surface area is represented by the forebay basin floor which consists of a granite ledge with a relatively low permeability and rock fill. Remediation methods expected for these surfaces are expected to be highly effective. Contamination levels for these surfaces were confirmed as part of the remediation

<sup>6</sup> Depth profile samples were collected at the location of the highest reported activities for sediment collected beneath the rip-rap in the tidal zone, i.e., "surface" sediment. See Section 2.1 in this attachment.

<sup>7</sup> "Surface" sediment activities, presented here for comparison, are the averages of the two sediment samples, collected immediately beneath the rip-rap, which reported the highest activity.

<sup>8</sup> These activities represent an average of the two samples taken at the listed interval, for example, dike soil collected and composited from the 0" to 6" interval.

process. From a dose assessment standpoint, a conservative surface contamination level (DCGL) was established to bound any contamination that may remain on the forebay/seal pit floor surfaces. See LTP Section 6.6.9.

<b>Table 2H-5. Summary Media Activity Data for the Forebay/Seal Pit (for the Principal Nuclides)</b>			
	<b>Co-60 pCi/g</b>	<b>Cs-137 pCi/g</b>	<b>Comment</b>
Forebay floor (and limited concrete surfaces)	*	*	Expected to be largely remediated with remediation of marine sediment. Conservative surface contamination level assumed in dose assessment.
Rip-rap rock surface	0.1	0.1	Based on both diffuser and rip-rap rock surface samples. (Co-60/Cs-137 ratio: Approx. 1.0)
Marine sediment near rip-rap <sup>9</sup>	19.7	1.1	Marine sediment is expected to be largely remediated in the initial stage of forebay/seal pit remediation. (Co-60/Cs-137 ratio: Approx. 18.0)
Dike "soil" material <sup>10</sup>	0.071	0.082	Material beneath rip-rap (Co-60/Cs-137 ratio: Approx. 0.9)

\*The Forebay was remediated to appropriate levels, an FSS completed, and the area released from the 10 CFR 50 License.

### 3. Diffuser, Contaminated Media Characterization

As noted above, the principal diffuser contaminated media included: (1) marine sediment likely redeposited back into the diffuser discharge piping (following the permanent shutdown of the plant circulating water system) and (2) the diffuser piping internal surfaces. From a dose standpoint, the principal dose contributor is the marine sediment entrained in the diffuser. The plant derived activity in this sediment originated in the plant's licensed liquid effluent releases (via the forebay). Then, with the securing of plant operations and the cooling water system, the tidal action transported benthic silt back into the diffuser system. Plant derived activity concentrations reported for marine sediment now inside the diffuser piping are higher than that

<sup>9</sup> Average of sediment samples collected beneath rip-rap. See Table 2H-2.

<sup>10</sup> Sample data from the 2002 forebay dike coring campaign. Values shown are averages from the samples that resulted in a positive detection. See Section 2.4.

measured in sediment outside the piping.<sup>11</sup> The higher sediment activity inside the piping is believed to be due to activity absorbed or incorporated into the sediment inside the piping from the liquid effluent discharges since the end of plant operations. Although the dose consequences of the licensed liquid effluent releases which resulted in the activity in the diffuser have already been accounted for and reported in the routine effluent release reports, a dose assessment of the activity conservatively assumed to remain in the diffuser is discussed in Section 6.6.9.

As a matter of completeness in this discussion, seaweed characterization data is also included here since it is considered as a potential contaminated media in the dose pathway analysis. See the discussion below.

### 3.1 Diffuser: Marine Sediment Inside Diffuser Piping

During diving operations and inspections of diffuser discharge piping, sediment samples were obtained and analyzed by gamma spectroscopy. This analysis provided the following average activities are included in Table 2H-6.

Table 2H-6. Diffuser Related Characterization Summary <sup>12</sup>			
	Co-60 pCi/g	Cs-137 pCi/g	Comment
Sediment inside diffuser discharge piping	1.1	0.15	Average activity. These sediment samples were also analyzed for HTDs. No HTD nuclides were detected. See EC 041-01. (Co-60/Cs-137 ratio: Approx. 7.3)
Diffuser inside piping surface	0.1	0.1	Average diffuser piping coupon activity. (Co-60/Cs-137 ratio: Approx. 1.0)
Seaweed	76.8	5.63	Average activity from forebay samples (as a conservative measure). See discussion in text. (Co-60/Cs-137 ratio: 13.6)

### 3.2 Diffuser Surfaces

During the above mentioned diving inspections of diffuser piping, coupons of the fiberglass piping were obtained and analyzed for surface contamination. The nuclides detected were Co-60 and Cs-137 at nearly equal activity. The activity levels detected

<sup>11</sup> Per LTP Table 2B-5, Package R2000, samples taken near the diffuser reported a maximum Co-60 activity of 0.12 pCi/g.

<sup>12</sup> See Attachment 3 of EC-041-01 for additional detail regarding diffuser characterization sampling, such as number of samples and individual results.

were very near the MDA of 0.1 pCi/g for each nuclide and appeared to be present on the surface as a tightly adhered, thin film of organic material. The physical appearance of this material on the piping surface was similar to that noted on the contaminated rip-rap surfaces. The activity levels of the diffuser piping surface was also comparable to that on the rip-rap, suggesting similar physical mechanisms for adhering and incorporation of contamination at work.

### 3.3 Seaweed Activity, Relevant to the Diffuser Dose Assessment

Seaweed is present in the forebay and shoreline areas around Bailey Point. Dose contributions via contaminated seaweed were considered in the diffuser dose model as a matter of completeness, even though the dose contribution was expected (and confirmed) to be low. Seaweed samples taken from shoreline locations have shown sporadic and low activity levels of radionuclide uptake. Seaweed samples taken from the forebay were used in the dose assessment as a conservative measure of any seaweed related dose.<sup>13</sup> See Section 6.6.9 for seaweed use, pathway assumptions, and dose results. The seaweed activity values presented in Table 2H-6 are associated with forebay samples but were applied to the diffuser dose assessment.

## 4. **Nuclide Fraction for Forebay/Diffuser Material**

In summary, characterization samples were obtained and analyzed from contaminated media associated with the forebay/seal pit structures, including sediment under water and around the rip-rap, material on exposed rock (near the weir), dike "soil" beneath the rip-rap, and rip-rap surfaces. Additional samples were taken and analyzed from sediment inside the diffuser piping, as well as material deposited on diffuser piping internal surfaces. HTD analyses were performed on 3 collections of sediment sampling sets: an earlier (MY) composite of 15 samples, two high activity samples from the exposed sediment material, and sediment collected from inside the diffuser piping. An examination of these results concluded that the original HTD sample set, used to establish the LTP Rev. 1 nuclide fraction are appropriate and conservative nuclide fractions. The sample analyses also consistently confirmed that Co-60 and Cs-137 were the principal nuclides of interest. As noted in Table 2H-7, the Co/Cs ratios for the various contaminated media are comparable, spanning the range of 10.1 to 19.8.

The Co/Cs ratios were, in general, found to be lower for lower activity samples, as would be expected. This was seen in the assessment of contamination on rip-rap and diffuser piping surfaces, as well as deeper dike soil samples. However, the use of a nuclide fraction with a much higher Co/Cs ratio, such as that in Table 2H-1, is conservative from a dose standpoint. See EC 041-01 for additional discussion.

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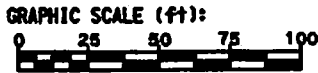
<sup>13</sup> Seaweed and other vegetative matter in the forebay will be removed during the sediment remediation work.

<b>Table 2H-7. Comparison of Co/Cs Ratios</b>			
	<b>pCi/g Co-60</b>	<b>pCi/g Cs-137</b>	<b>Co/Cs Ratio</b>
LTP Rev. 1 forebay sediment NF (Table 2H-1)	NA	NA	18.9
Sediment around rip-rap in tidal zone (Table 2H-2)	19.7	1.1	18.0
Exposed sediment material (Section 2H-2.2a)	65.9	3.3	19.8
Underwater sediment, forebay and seal pit (Section 2H-2.3)	19.0	1.9	10.1
Dike "Soil," underneath rip-rap (Data from 2002 dike coring campaign. See Section 2.4)	0.071	0.082	0.9

The forebay dose assessment confirmed that nuclides other than Co-60 and Cs-137 represent only a small fraction of the dose contribution.

Thus, considering the overall dominance of Co-60 and Cs-137 nuclides in the dose impact, the comparable Co/Cs ratios for forebay/diffuser materials, and the effective absence of TRU nuclides, an overall evaluation of this characterization data concluded that a single nuclide fraction, determined by HTD analyses was appropriate for application to forebay/diffuser media. Further assessment and comparison of the HTD analyses concluded that the originally determined nuclide fraction, established in the LTP Rev. 1 analysis of forebay sediment, remained appropriate and conservative for dose assessment application to forebay and diffuser contaminated media. See EC 041-01 for additional detail and discussion of the data evaluation.





● 19.8 APPROXIMATE SAMPLE LOCATIONS  
INDICATING Co-60 (pCi/g) LEVELS

— DIKE TOPOGRAPHY

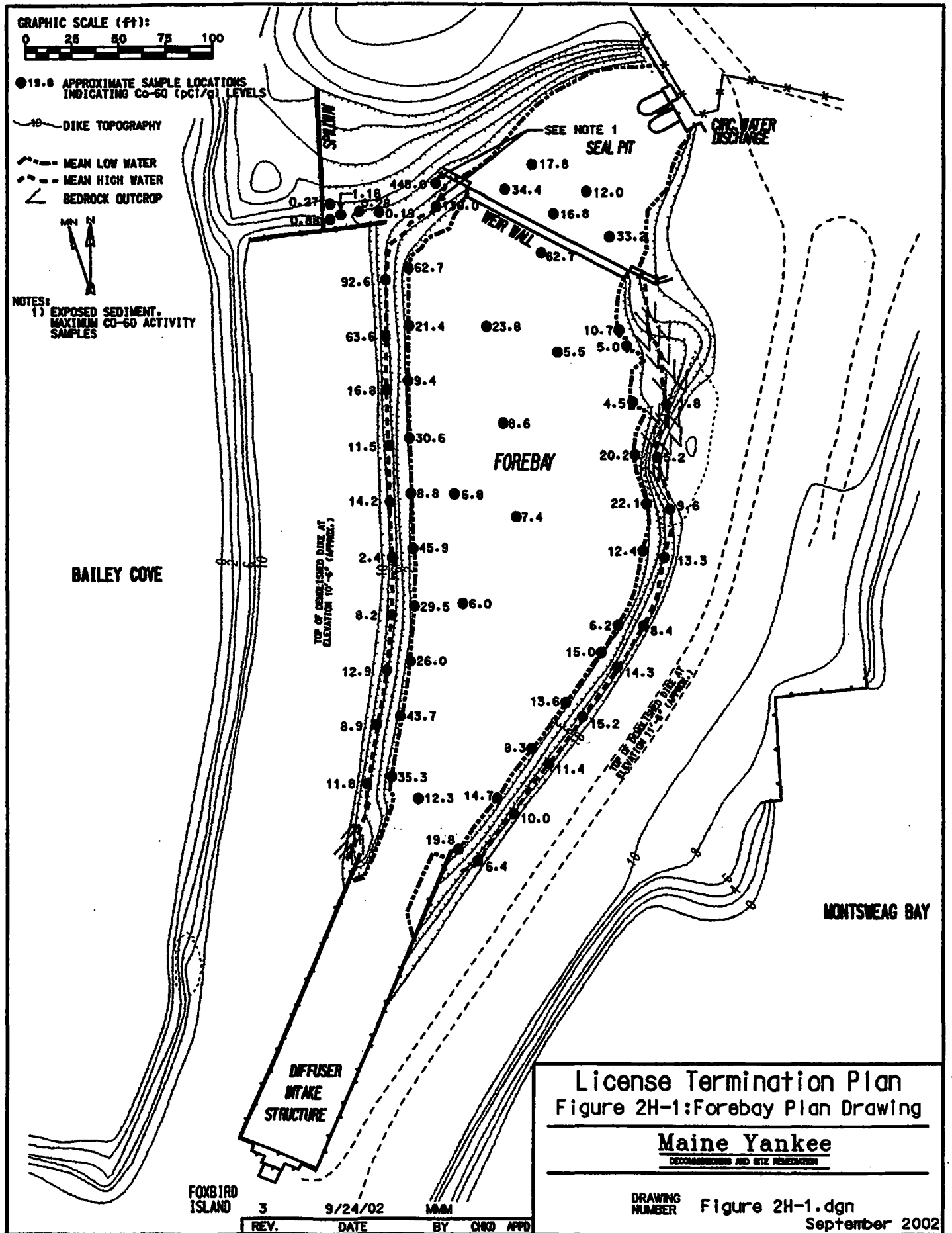
- - - MEAN LOW WATER

- - - MEAN HIGH WATER

▲ BEDROCK OUTCROP



NOTES:  
1) EXPOSED SEDIMENT,  
MAXIMUM  
CO-60 ACTIVITY  
SAMPLES



License Termination Plan  
Figure 2H-1: Forebay Plan Drawing

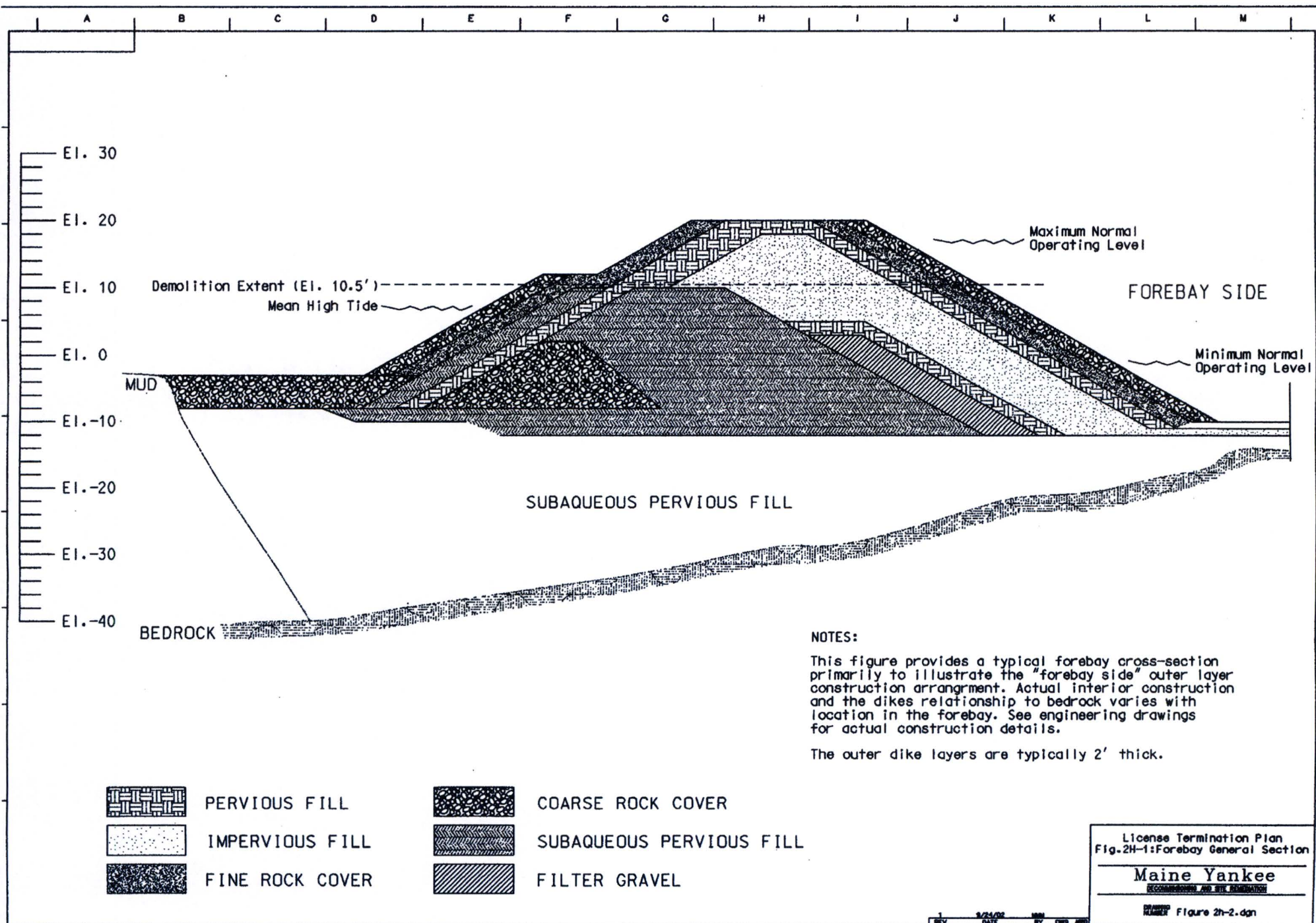
**Maine Yankee**

DECOMMISSIONING AND SITE REMEDIATION

DRAWING  
NUMBER

Figure 2H-1.dgn

September 2002



## **ATTACHMENT 2I**

### **Soil Sampling and Radionuclide Fraction**

## Soil Sampling and Radionuclide Fraction<sup>1</sup>

### Introduction

Multiple soil samples representing areas of the site known to have high activity soil contamination were collected. Several samples from each area were composited to provide the most representative contaminated soil values and provide the highest probability to detect and quantify hard-to-detect (HTD) radionuclides that could be associated with the contaminated soil. Specific instructions were included for composition and analysis of these samples so as to insure the representation of the samples to be submitted for HTD vendor lab analysis. Since the final status surveys for soil include gamma spectroscopy analysis of each soil sample, the HTD data set is useful for establishing the surrogate relationship to Cs-137. These HTD nuclides (H-3 and Ni-63) contribute to less than one percent of the total soil dose.

### Sample Analysis

A comparison of specific soil nuclide parameters over time (1999- 2030) was made to determine how the soil Cs-137 surrogate DCGL value changes with time. The DCGL ranges from about 4.2 to 4.4 pCi/g. The change is mostly due to the fact that Co-60 decays at a faster rate than Cs-137, which results in higher allowable surrogate DCGL levels at later times. This variation with respect to time shows that the effect of conducting final status surveys significantly sooner or later than the currently proposed time is insignificant. In practice, the Co-60 will be measured by gamma spectroscopy and the only nuclides included in the Cs-137 surrogate calculations will be H-3 and Ni-63. The total dose from H-3 and Ni-63 in soil is about 0.1 mrem/y as calculated for the year 2004. Any changes in dose from these radionuclides over time will be negligible (<0.02 mrem/y) relative to the unrestricted use criteria.

### Sample Selection and Composition

To determine the best representation of Industrial and Restricted Area samples the soil samples and respective locations collected during the GTS Site Characterization were examined. Emphasis was placed on samples collected from areas of principle spill or contamination incident. These areas of significance were the RWST, PWST and the Shielded Radiological Waste Storage Area (SRWSA). Examination of all other site characterization soil samples showed that these three areas contained the maximum concentration of elevated soil activity. The available GTS vendor laboratory results for some samples from these areas showed relatively high MDA values for several HTD nuclides. Any positive TRU results were at or very near MDA values and those near the MDA value did not appear in the ratios of one nuclide to another, which would be expected in power reactor TRU inventory. From these observations it was decided to composite biased samples of maximum concentration from the regions of the most significant incidents. The twelve samples that were composited for these areas originated

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<sup>1</sup> The soil sample analysis results and general methodology are presented in Engineering Calculation EC 013-01, Rev. 0. This calculation reviews the associated sample results and encompasses the features and nuclides associated with Engineering Calculation EC 007-00, Rev 1.

from the archived GTS site characterization soil samples and are expected to represent greater location diversity and better estimate of distribution than individual sample locations.

Inspection and composite instructions were developed in the form of a technical evaluation document so that all samples were systematically processed in the same manner and using the same methodology. Once the twelve archived samples were located, the samples were assigned a new chain-of-custody form and a minimum of one sample from each group (RWST, PWST and SRWSA) was analyzed in the original GTS retransmit beakers using the Maine Yankee gamma spectroscopy system. As one of the instruction steps, the Maine Yankee spectroscopy Cs-137 analysis results were compared to the original GTS Cs-137 results and found to reasonably agree. As stated, the Maine Yankee analysis results conclude that the principle gamma emitters associated with the original GTS soil sample containers were within reasonable agreement of the concentrations reported in the GTS Characterization Report.

Following this comparison and per the composite instructions each of the GTS samples for each of the three regions (RWST, PWST and SRWSA) were thoroughly mixed and a predetermined sample mass collected of the composite representing each region. From the original Cs-137 concentration associated with each sample, the concentration per unit mass and total mass of the sample was estimated. These results were compared to the composited sample results. This comparison provides both a final check of the reported concentrations to the current analysis and insight into the distribution of associated radionuclides in the media. The narrow range of concentration variation associated with the RWST estimated and final composite values is indicative of contaminants associated with liquids where the concentration would expectedly be more uniform. The wider range of variation for the PWST and Shielded Storage areas estimated and final composite values are indicative of non-uniform contaminants and for a given sample group the range variation would represent the spatial distribution of the activity in the media. Table 2I-1 presents these findings.

**Table 2I-1**  
**Original and Composite Cs-137 Soil Concentrations and Comparison**

	GTS Samples	Estimated Collective Value		Final Composite Value	
Sample Location	Cs-137 Range	Weight (g)	Cs-137 (pCi/g)	Weight (g)	Cs-137 (pCi/g)
RWST	11.0 -114.0	1440.0	61.6	1475.0	60.5
PWST	14.6 - 156.0	1500.0	86.1	1532.0	99.4
Shielded Storage	18.3	800.0	18.3	1023.0	22.1
All RWST samples represent surface soil; Two PWST soil samples (Cs-137 ranging from 14.6 - 57.6 pCi/g) represent soil at 6-18 inch depths. Three PWST sample represent Cs-137 surface soil ranging from 69.1-156 pCi/g. The single Shielded Storage sample is surface soil.					

### **Additional Confirmatory Sample Collection**

The continued characterization soil samples (442 samples) collected in 1999 and 2001 support the observed composite results obtained from the samples associated with the RWST, PWST and SRWSA.

These investigations focused primarily in the Industrial and Restricted Area of the site. Only Co-60 and Cs-137 were identified in the 442 samples. These samples represented both surface and subsurface investigations to a depth of nearly 4 meters (~12 feet). The concentration range of all these samples was significantly lower than the samples used for the soil profile provided in EC-013-01 (See Table 2I-2 below).

A total of 442 samples from 107 locations were collected and analyzed. The sample analysis results (442 samples) showed that Cs-137 was reported at >MDA 35.5 percent of the time while Co-60 was reported at >MDA only 2.0 percent of the time. The results of these samples provide additional support for Cs-137's predominate presence in contaminated site soils. DCGL values show that the surrogate DCGL changes little over time (~2.6% from 2004 to 2030). The maximum observed soil concentrations for Cs-137 and Co-60 in the 1999 and 2001 sample results (442 samples) were considerable lower (Cs-137: 34.7 and Co-60 12.4 pCi/g) than the composited samples used to determine the HTD soil constituents. These results indicate that the analyzed composites conservatively address the HTD and gamma emitters associated with the site soils. Of the 422 samples 79 were determined to exceed the action level estimated for the sampling plan.

Table 2I-2 presents the range of Co-60 and Cs-137 for the 79 samples that were found to exceed the sample plan respective Action Levels of 1.0 and 3.1 pCi/g for Co-60 and Cs-137. It is important to note that for the Co-60 data in Table 2I-2 only seven Co-60 sample results are above the MDC for the analysis parameters (The reported Co-60 MDC's for the remaining 72 samples ranged from 0.05 to 0.40 pCi/g). For the Cs-137 data in Table 2I-2 a total of 58 (73.4%) of the 79 samples are above the MDC for the analysis parameters (The 21 Cs-137 samples less than the MDC ranged from 0.06 to 0.41 pCi/g). The results of Table 2I-2 show that none of the 442 additional samples collected approached the soil concentrations reported for the RWST and PWST composite samples. As previously stated the radionuclide results of the RWST and PWST samples conservatively characterize the Maine Yankee site soils.

**Table 2I-2**  
**Cs-137 and Co-60 Range for Continued Characterization  $\geq$  Action Level\***

<b>Cs-137 Range (pCi/g)</b>	<b>Number of Observations</b>	<b>Co-60 Range (pCi/g)</b>	<b>Number of Observations</b>
>0.34 -2.0	33	>0.06 - 0.50	36
>2.0 - 5.0	22	>0.50 - 1.0	27
>5.0 - 10.0	15	>1.0 - 2.0	15
>10.0 - 20	3	12.4	1
>20 - 34.7	6		
Total	79	Total	79

\*Sample Plan Action Level 1.0 and 3.1 pCi/g for Co-60 and Cs-137 respectively.

### Summary

- The soil characterization by GTS and sample locations throughout the Restricted Area (RA) and Industrial Area (IA) were reviewed. Sample locations were selected that reflected locations of historic primary contamination incidents and highest soil contamination.
- The concentrations of the selected samples increase the probability of detecting and quantifying HTD nuclides.
- The composite method used resulted in composite soil concentrations conservatively higher than any of the GTS characterizations soil samples and the 442 continued characterization samples acquired in the RA and IA in 1999 and 2001.
- All FSS soil samples will be analyzed using gamma spectroscopy.
- The 442 continued characterization soil samples collected in 1999 and 2001 support the composite results.
- The Cs-137 surrogate DCGL for soil varies no more than 2.6% from 2004 through 2030 (~4.0% from 1999 through 2030).

**MAINE YANKEE**

**LTP SECTION 3**

**IDENTIFICATION OF REMAINING SITE DISMANTLEMENT ACTIVITIES**



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### ATTACHMENT 3A

Drawing Associated with Specific Decommissioning Tasks

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### **3.0 IDENTIFICATION OF REMAINING SITE DISMANTLEMENT ACTIVITIES**

#### **3.1 Introduction**

##### **3.1.1 Purpose**

This section of the LTP describes the remaining dismantlement activities at MY pursuant to 10 CFR 50.82(a)(9)(ii)(B) and following the guidance of NUREG 1700 and Regulatory Guide 1.179. Information is presented to demonstrate that these activities will be performed in accordance with 10 CFR Part 50 and will not be inimical to the common defense and security or to the health and safety of the public pursuant to 10 CFR 50.82(a)(10). Information which demonstrates that these activities will not have a significant effect on the quality of the environment is provided in LTP Section 8.

The dismantlement activities described in this section provide the NRC the information to support their determination to terminate the license pursuant to 10 CFR 50.82(a)(11)(i). Therefore, this section was written to clearly indicate each dismantlement activity which remains to be completed prior to qualifying for license termination. Furthermore, information is provided on the final state of the site including structural remnants, basement foundations and buried piping and conduits. This information ensures that the scope of any possible residual contaminated materials associated with the final state of the site are considered in dose modeling, survey design and environmental assessment. Any changes to the dismantlement activities described in this section which are made pursuant to 10 CFR 50.59 must also consider the impact of those changes on the final state of the site and any impacts on dose assessment, survey design or environmental assessment.

Information related to the remaining decontamination and dismantlement tasks is also provided. This information includes an estimate of the quantity of radioactive material to be released to unrestricted areas, a description of proposed control mechanisms to ensure areas are not recontaminated, estimates of occupational exposures, and characterization of radiological conditions to be encountered and the types and quantities of radioactive waste. This information supports the assessment of impacts considered in other sections of the LTP and provides sufficient detail to identify inspection or technical resources needed during the remaining dismantlement activities. Many of these dismantlement tasks require coordination with other federal, state or local regulatory agencies or groups. Maine Yankee's coordination with these agencies and groups is generally described.

An evaluation of the remaining decontamination and dismantlement activities is described in this section. This evaluation presents summary supporting justification for the conclusion that, pursuant to 10 CFR 50.59, activities may be conducted without obtaining a license amendment pursuant 10 CFR 50.90. Where activities require Maine Yankee to obtain a license amendment, such activities are identified along with the corresponding schedule for the proposed license amendment and the schedule for needed approval.

### 3.1.2 Decommissioning Progress Update

Shortly after the submittal of the 10 CFR 50.82(a)(1) certifications, Maine Yankee assembled a System Evaluation Review Team (SERT) to evaluate each plant system, structure and component (SSC) against applicable regulatory and design basis requirements. These evaluations resulted in the classification of SSCs as available and/or abandoned. Applicable systems were drained, de-energized and deactivated as appropriate for turnover to the Decommissioning Operations Contractor (DOC). The reactor coolant system was chemically decontaminated to reduce source term in preparation for dismantlement.

During the fall of 1997 and spring of 1998, Maine Yankee conducted a radiological characterization of the site through GTS Duratek. Appropriate historical information was compiled into the Historical Site Assessment (HSA). This site characterization, which is summarized in LTP Section 2, was conducted to assist companies bidding for a contract to decommission the site with additional characterization to be conducted as necessary thereafter. During the fall of 1998, Maine Yankee reviewed bids and selected Stone & Webster as the DOC. Under Maine Yankee oversight, Stone & Webster conducted various decontamination and dismantlement activities until May 2000 when the contract was cancelled.

The overall project schedule defines the current status and remaining activities. As of September 30, 2005, the decommissioning of the site is complete, with the exception of the area associated with the ISFSI and a parcel of land adjacent to the ISFSI.

The construction of the ISFSI has been completed, and movement of spent fuel was completed in the first quarter of 2004. In preparation for constructing the ISFSI, final status surveys of the land area and the ISFSI Security Operation Building (SOB), formerly the Low Level Waste Storage Building (LLWSB), were initiated in the fall of 1999 through summer of 2000. In preparation for fuel transfer, Maine Yankee conducted a complete inventory and inspection of the contents of the spent fuel pool during 2000.

The major decommissioning activities, with the exception of those associated with the decommissioning of the ISFSI, have been completed. Reactor coolant system piping, reactor coolant pumps and motors, steam generators and the pressurizer have been removed and shipped offsite for processing and/or waste disposal as appropriate. Other small commodities have also been removed and shipped offsite. Reactor vessel internals were segmented using an abrasive water jet (AWJ) system. Greater-than-class-C (GTCC) waste generated as a result of the segmentation project were loaded into NAC UMS casks and stored onsite at the ISFSI. During 2003 and 2004, remaining above grade structures in the Industrial Area were surveyed and demolished including the Spray Building, Primary Auxiliary Building, Fuel Building and Containment Building.

On January 3, 2001, Maine Yankee submitted an application to amend the license to release a portion of the site classified as non-impacted. This application provides the NRC with the information specified in LTP Section 1.4.2. This land area contains a few structures including the Eaton farmhouse. While some non-radiological remediation was conducted on the farmhouse, no dismantlement activities are required to be completed prior to removing this land area from the jurisdiction of the Part 50 license as requested in the proposed license amendment. On April 10, 2001, Maine Yankee submitted a second application to amend the license to release an additional portion of the site classified as non-impacted. On August 16, 2001, Maine Yankee resubmitted its application to release these lands, combining the previous two applications into one application and revising the presentation of the characterization data and results. Statistical analyses were presented to demonstrate that the residual activity, if any, in these lands is indistinguishable from background. On November 19, 2001, Maine Yankee supplemented its combined application, making certain clarifications including land survey information. The NRC granted this request for the release of these lands in July 2002. See Section 1.4.2.

On March 15, 2004, Maine Yankee submitted letter MN-04-020 requesting an amendment to the facility operating license pursuant to 10 CFR 50.90 and in accordance with the NRC Approved LTP for Maine Yankee, to indicate NRC's approval of the release of the Non-ISFSI site land from the jurisdiction of the license. From March 2004 to July 2005, Maine Yankee submitted supporting final status survey reports, supplements to the amendment and responses to NRC requests for additional information. On September 30, 2005, NRC issued Amendment No. 172 consisting of the unrestricted release of the remaining land under License No. DPR-36 with the exception of the land where the ISFSI is located and a parcel of land adjacent to the ISFSI.

### 3.1.3 Decontamination & Dismantlement Process Summary

Decontamination & dismantlement activities will be supported by detailed project planning and scheduling. This planning supports as low as reasonably achievable (ALARA) reviews, estimation of labor and resource requirements, while tracking cost and schedule. Work packages are used to implement the detailed plans and provide

instructions for actual field implementation. The work packages address described units of work and include appropriate hold and inspection points. Administrative procedures control work package format and content, as well as the review and approval process.

Systems and components removed and released from the secondary side of the plant for commercial disposal were surveyed in accordance with plant procedures based upon a no detectible radioactivity standard. The controlling procedure specified that the instrumentation must be capable of detecting beta/gamma (and alpha if suspected) radioactivity<sup>1</sup> at or below the levels listed below:

- a. Total surface beta/gamma contamination @5000 dpm/100 cm<sup>2</sup>
- b. Loose surface beta/gamma contamination @1000dpm/100 cm<sup>2</sup>
- c. Fixed alpha contamination @100 dpm/100 cm<sup>2</sup>
- d. Loose surface alpha contamination @ 20 dpm/100 cm<sup>2</sup>
- e. Gamma dose rates of 10 micro rem/hr

This procedure required that material be evaluated for probability of radioactive contamination by utilizing "knowledge of process" which may include review of surveys, the historical site assessment, characterization surveys or other knowledge of material history. Survey requirements were increased according to the greater probability for contamination. For instance, materials with no probability for contamination were subject to an aggregate dose rate survey and a validation survey which included a truck monitor or acceptable alternative. Materials with a low probability for contamination were subject to a biased direct frisk (typically approx. 10% of surface area) and loose surface contamination survey prior to packaging as well as the above requirements for aggregate and validation survey following packaging. Materials with a high probability for contamination were subject to the above requirements for low probability materials however the entire accessible surface area of the materials were subject to a direct frisk prior to packaging. Additional or alternative survey requirements were also specified for special situations including volumetric materials, difficult to survey items, systems or components and samples.

A separate procedure was implemented with the same detection levels, augmented by additional controls for the release of material from the radiologically restricted area. Generally, systems and components removed from the primary (radiologically controlled) side of the plant were packaged and either transported to an offsite processing facility, a low-level radioactive waste (LLRW) disposal facility, or an appropriate disposal facility.

Decontamination of structures included a variety of techniques ranging from water washing to surface material removal. Structural material may be

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<sup>1</sup> In accordance with NRC Circular 81-07 and IE Information Notice No. 85-92

packaged and either transported to an offsite processing facility, a LLRW disposal facility, or an appropriate disposal facility.

Following the removal or decontamination of systems, components, and structures associated with the ISFSI, a comprehensive final status survey (FSS) will be completed as described in Section 5 of this LTP. The decommissioning cost estimate for the ISFSI assumes that the material that comprises the ISFSI storage pads and Vertical Concrete Casks will be demolished and disposed of as low-level radioactive waste.

The ISFSI is designed, constructed and loaded with spent fuel and GTCC waste stored in casks during this Phase. Maine Yankee's storage of spent fuel in the ISFSI will be conducted under a general Part 72 license pursuant to 10 CFR Part 72, Subpart K. Therefore, Maine Yankee will store fuel only in fuel casks approved by the NRC as listed in 10 CFR 72.214. The GTCC waste is stored in accordance with 10 CFR 30, and is co-located with the stored spent fuel as evaluated in the 10 CFR 72.212 Evaluation Report. The ISFSI and the associated areas will be decommissioned following removal of the spent fuel and GTCC waste from the site.

### 3.2 Remaining Dismantlement Activities

The purpose of this section of the LTP is to indicate each dismantlement activity which remains to be completed prior to qualifying for license termination. This information is provided to support the NRC in making their determination to terminate the license pursuant to 10 CFR 50.82(a)(11)(i). In addition to identifying the dismantlement activities, information is provided on the final state of the site including structural remnants, basement foundations and buried piping and conduits. This information ensures that the scope of possible contaminated materials associated with the final state of the site are considered in dose modeling, survey design and environmental assessment. Any changes to the dismantlement activities described in this section which are made pursuant to 10 CFR 50.59 must also consider the impact of those changes on the final state of the site and any impacts on dose assessment, survey design or environmental assessment.

#### 3.2.1 Major Decommissioning Activities

10 CFR 50.2 defines "major decommissioning activity" as any activity that results in permanent removal of major radioactive components, permanently modifies the structure of the containment, or results in dismantling components (separating and packaging GTCC waste) for shipment in accordance with 10 CFR 61.55.

The only remaining decommissioning activities are those associated with the ISFSI and associated areas. Following removal of the spent fuel and GTCC waste from the site, the ISFSI and the surrounding areas will be decommissioned. The decommissioning cost estimate assumes that the materials that comprise the ISFSI storage pads and Vertical Concrete Casks will be demolished and disposed of as low-level radioactive waste.



### 3.2.2 Dismantlement Activity Schedule

The few facilities and structures required to support the ISFSI (spent fuel and GTCC waste storage) will be decontaminated, as necessary, and dismantled after USDOE has removed the stored materials. This is currently scheduled to occur in 2034, with license termination in 2036.

Table 3-1 Major MY Area/Systems, Structures, and Components Removed (By Year)	
2034 through 2035 (or after DOE removes the stored materials)	
ISFSI site D&D with remediation as required	

The remaining decommissioning schedule represented in Table 3-2 will be revised during the project.

Table 3-2 Area of Activity & Decommissioning Activities Schedule (Arranged Chronologically)			
Activity Number		Activity Description	Completion Date
		ISFSI Dismantlement, Decommissioning and Remediation (After removal of all spent fuel)	2034-2035**
		Dismantlement of structures, support buildings, fences, lighting and utilities poles	2034-2035*
		Site Remediation, planting of grass, trees, etc	2036**
		Final Facility Site Survey	2036**
		Release of the Facility Site for unrestricted use	2036**
		Termination of Maine Yankee Atomic Power Company's Part 50 License	2036**

\*\* Calendar year 2034 is the projected date for DOE to have taken possession and removed stored materials.

### 3.2.3 Final State-of-the-Site Description

The purpose of this section is to present a conceptual description of the site following license termination and unrestricted release and to identify the extent of the types of media that must be considered in dose assessment, survey design and environmental assessment. Figure 3-30 shows the anticipated final state of the site. At license termination, when the site will be released for unrestricted use, the site will be a backfilled and graded land area with possibly some above grade structures remaining depending on the industrial reuse of the site. Generally speaking, all of the above grade structures will be demolished to three feet below grade and the resulting concrete demolition debris will be disposed of offsite at either a low-level waste facility or an appropriate disposal facility except for the 345 & 115 kV switchyards and possibly other administrative buildings. The remaining basement foundations will be filled with a soil fill material following any required remediation and FSS activities.

The former Low Level Waste Storage Building [now the ISFSI Security Operations Building-(SOB)] will remain in place until the fuel is transferred to the USDOE. The 115 kV switchyard and the 345 kV switchyard, will remain intact. The road that travels past the ISFSI will remain in place, terminating near the 115 kV switchyard. The original plant access road will remain. The existing railroad will remain in place. The Old Ferry Road (a public road) and public boat ramp will remain in place.

As of September 30, 2005, the only areas that remain within the control of the 10 CFR 50 License are the area associated with the ISFSI and a parcel of land adjacent to the ISFSI.

After the DOE transports all the stored spent fuel and GTCC waste from the ISFSI, it will be decontaminated, if necessary, and demolished down to three feet below grade. A Final Status Survey will be performed for remaining lands and/or structures.

### 3.3 Methods of Decontamination and Dismantlement

Structure decontamination methods typically include wiping, washing, vacuuming, scabbling, spalling, and abrasive blasting. Selection of the preferred method is based on the specific situation. Other decontamination technologies will be considered and used if appropriate.

If structural surfaces are washed to remove contamination, controls are implemented in accordance with approved plant procedures to ensure that wastewater is collected for processing by liquid waste processing systems. Airborne contamination control and waste processing systems are used as necessary to control and monitor releases.

Concrete that is activated will be removed down to the activated concrete DCGL and sent to a low level radioactive waste disposal facility. Removal of contaminated (non-activated) concrete will be performed using methods that control the removal depth to minimize the waste volume produced. Appropriate engineering controls for control of dust and debris will be used to minimize the spread of contamination and reliance on respiratory protection measures.

The decommissioning cost estimate assumes that the material that comprises the ISFSI storage pads and Vertical Concrete Casks will be disposed of as low-level radioactive waste.

The following structural decontamination methods are described:

a. In-situ Concrete Decontamination by Bulk Removal

Diamond wire saw cutting may be used for the removal of volumetric concrete above the unrestricted use criteria, (or DCGL).

The removal of concrete consisting of the upper 1 or 2 feet of a thick slab such as a building foundation mat will require volumetric removals beyond the limits of scabblers or shot blasting. Whether due to activation or to leakage of liquids into concrete, the material may be removed using a mini-hoe ram or demolition robot. These have the flexibility to access congested areas and can be controlled to limit the volume of waste produced.

b. In-situ Surface Decontamination of Concrete

The expected depth of the contamination will establish the process used for the surface decontamination of concrete. Scabblers and shot blasting equipment fitted with vacuum collection systems may be used for surfaces with deeper contamination. Elsewhere, sponge blasting using one or more different media and wipe downs with solvents may be used. Cross-contamination and recontamination will be minimized using the vacuum collection systems.

c. Decontamination of Plant Concrete Structures That Are to Be Demolished (located higher than three feet below grade)

Contaminated concrete structures above three feet below grade may not be completely decontaminated. They will be packaged and shipped off site for disposal at a LLRW disposal facility or appropriate disposal facility.

d. Concrete Surfaces Located at Elevations Lower than Three Feet below Grade

Concrete surfaces below three feet below grade will be decontaminated if required to established criteria.

e. In-situ Surface Decontamination of Metals/Preparation of Metal - Surfaces for Segmentation

Most metallic wastes will not be decontaminated on site. Sponge blasting using various media ranging from non-aggressive for surface cleaning to heavy abrasive media or other methods for paint or oxide removal will be used and/or wipe downs with solvents. The contamination on exterior and/or interior metallic surfaces may be fixed prior to dismantling the structure or component.

Steel located within non-RA buildings, i.e., not considered to have been exposed to radiological contamination, will be surveyed and released for demolition. The external structural steel of plant buildings has been assessed during walkdowns and, depending upon the area, will either be surveyed and released for demolition or dismantled for packaging and shipment to a waste processor.

Table 3-3 describes the structures and facilities within the scope of the decommissioning along with the condition of release and final configuration.

<b>Table 3-3 Structures and Facilities Within the Scope of Work for Demolition</b>		
<b>Building or area description</b>	<b>Condition of release</b>	<b>Final configuration of structure</b>
ISFSI Storage Pads	1	Demo.
Vertical Concrete Casks	1	Demo.
Security / Operations Building	1	Demo. 3 ft below grade; backfill
Vertical Concrete Cask Construction Pad	3	Demo.
Vehicle Barrier System	3	Demo.
Protected Area Lighting, Fencing, and Intrusion Detection Systems	3	Demo.

Property, structures and facilities will be demolished to a level three feet below present grade, with few exceptions. As a result of this approach, the following sequence of dismantlement and demolition will occur for buildings with Condition of Release 1 identified in Table 3-3:

- a. Strip, package, ship commodities from the buildings (piping, steel, components, etc.) Commodities, including building steel determined to be clean may be released to the demolition contractor.
- b. Perform decontamination of the building concrete surfaces (at elevations below 3 feet below grade) to meet established criteria levels. Package the debris from decontamination and ship for LLW processing and/or disposal.
- c. Perform a final survey (sequence of "c" and "d" optional as described in section 3.1.3 )
- d. Release for demolition.

- e. Demolish the building structure to 3 feet below grade. Separate the clean<sup>2</sup> rebar from the concrete.
- f. Prepare the demolished concrete for shipment offsite.
- g. Release rebar using established radiological release procedures and ship rebar to metal recycling contractor.

The structures specified as Condition of Release 2 in Table 3-3, are those that are on the cold side of the plant and have been maintained as radiologically "clean," with the exception of some systems and equipment that may have internal contamination. Within these areas, the process for demolition will follow this process:

- a. Remediate, package, and ship systems, components and, commodities identified within the site characterization report and assessed and bounded by Maine Yankee. Structural steel of plant buildings will either be surveyed and released for recycling or dismantled for packaging and shipment as LLW material.
- b. Decontaminate, if required, to achieve the established radiological release criteria.
- c. Perform radiation surveys to allow material release to the demolition contractor.
- d. Release for demolition to the contractor.
- e. Demolish structures and foundations to depth specified.
- f. Subsurface piping to be handled as indicated above.
- g. Perform final grade.

The buildings, structures, and facilities identified as Condition of Release 3 in Table 3-3 are those that do not have a history of contamination and are therefore classified as "presumed clean." In certain cases there were minor exceptions to this generalization, based upon the information in the site characterization report, such as a small area within the information center and the staff building, that appear to have been remediated. Also, the site characterization report identifies higher activity levels within the basement of the environmental lab (Bailey House), that may be attributed to background from the granite. However, Maine Yankee will evaluate and release these individual areas in accordance with plant radiological release procedures to allow for demolition. Procedural controls

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Clean rebar has no detectable, plant-derived radioactivity associated with it. Rebar will be surveyed in accordance with free release criteria and disposed of as scrap. If activated rebar is discovered it will be disposed of as radwaste.

identify the monitoring requirements for construction debris release (Refer to Section 3.1.3).

Therefore, buildings, structures, and facilities identified as Condition of Release 3 in Table 3-3 will be processed as follows:

- a. Remove ancillary equipment required for asset recovery (furniture, etc.) - (It is assumed that Maine Yankee will remove equipment designated for asset recovery, prior to the scheduled remediation/ demolition of the structure).
- b. Perform survey in accordance with established procedures and criteria.
- c. Release for demolition to the contractor.

### 3.4 Evaluation of Dismantlement Activities

#### 3.4.1 Systems Review

The license basis status of Maine Yankee systems, structures, and components (SSC), is summarized in Table 3-4. As of September 30, 2005, the only areas that remain within the control of the 10 CFR 50 License are the area associated with the ISFSI and a parcel of land adjacent to the ISFSI.

#### 3.4.2 System Deactivation

Systems or components will continue to be abandoned/deactivated prior to decontamination, if necessary and dismantlement. In general, deactivation is implemented by mechanical isolation of interfaces with operating plant systems, draining piping/components, and de-energizing electrical supplies. Combustible material is removed from abandoned/deactivated components where possible. Chemicals used in, or resulting from, decommissioning activities are controlled in accordance with the applicable chemical safety program. Plant drawings are revised to indicate abandoned/deactivated portions of systems. Plant procedures are modified to reflect the changes when applicable.

Abandonment/deactivation of plant systems is controlled by approved plant procedures. The deactivation plans are established to implement the desired system valve lineup changes and electrical isolations. The design change process is used to remove components, lift electrical leads, install electrical jumpers, cut and cap piping systems, or install blank flanges as appropriate.

Plant procedures provide controls over the operation of deactivated system boundary valves. As additional systems are deactivated, existing isolation boundaries are re-evaluated and changed, as necessary, to reflect the new plant condition. Mechanical boundaries of abandoned SSCs (including boundary valves) are specifically identified in accordance with Maine Yankee's procedures

Temporary liquid and solid waste processing systems may be used during decommissioning for processing plant waste. These systems may include filters and/or demineralizers and may be used at one or more locations in the waste-processing path. Localized temporary ventilation equipment and HEPA filtration may be used to minimize the spread of radioactive particulate contamination.

<b>Table 3-4</b> <b>Status of Major MY Systems, Structures, and Components</b>		
<b>System/Component/Structure</b>	<b>Required for ISFSI Operations</b>	<b>Status</b>
Radiation Monitors Mounted on Protected Area Fence	NO	In Use
Electrical systems	YES	Portion maintained to support ISFSI operations
Fire protection systems	YES	Portion maintained to protect records in storage
ISFSI Storage Pads	YES	In Use
Vertical Concrete Casks	YES	In Use
Vertical Concrete Cask Construction Pad	NO	Pad will be demolished as part of ISFSI decommissioning
Vehicle Barrier System	YES	In Use
Protected Area Lighting, Fencing, and Intrusion Detection Systems	YES	In Use
ISFSI Security and Operations Building	YES	In Use



### 3.4.3 Nuclear Safety and Regulatory Considerations

The following general considerations, as applicable, will continue to be incorporated into packages during the decommissioning period. . During the decommissioning period, dismantlement activities will be reviewed to ensure that they do not impact safe storage of fuel and GTCC wastes in the ISFSI licensed under a general Part 72 license. Work packages are implemented in accordance with administrative controls. When applicable, decommissioning work is reviewed against the requirements of 10 CFR 50.59, 50.82(a)(6) and/or 72.48 to ensure work that is being performed without prior NRC approval does not need a license amendment.

Dismantlement activities will be conducted to ensure the safe storage of spent fuel and to protect the public health and safety as well as the common defense and security.

Important-to-Safety SSCs associated with the ISFSI and the NAC UMS cask are specified in Appendix A to the Maine Yankee Quality Assurance Program.

<p><b>Table 3-5</b> Deleted</p>
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## 3.5 Radiological Impacts of Decontamination and Dismantlement Activities

### 3.5.1 Waste Characterization

The MY Decommissioning Project Waste Management Plan includes waste disposal strategies, and addresses issues such as: estimates of the quantity of radioactive material to be released, control mechanisms, and radioactive waste characterization. Radioactive waste has been characterized by sending representative samples for 10 CFR Part 61 analysis. Table 3-6 lists the nuclides for which the samples were analyzed. Table 3-7 presents typical sample Part 61 analysis results.

### 3.5.2 Radioactive Waste Projections

Any data provided herein are estimated values and may or may not represent actual final volumes. The subject values shown in Table 3-7 provide relative fractions of nuclides historically present in Maine Yankee's waste streams. This and other information sources were used to identify those nuclides which were

requested for Part 61 analyses. Alternate means and methods may be utilized when appropriate to reduce these volumes.

As of September 30, 2005, the only remaining decommissioning activities for the site are those associated with the ISFSI. The decommissioning cost estimate assumes that the materials comprising the ISFSI storage pads and the Vertical Concrete Casks will be disposed of as low-level radioactive waste. It is not anticipated that this material will need to be removed to satisfy the NRC dose criteria for license termination.

**Table 3-6**  
**Nuclides Checked for by 10 CFR61 Analysis**

<b>Nuclide</b>	<b>Principal Emission★</b>	<b>Nuclide</b>	<b>Principal Emission★</b>	<b>Nuclide</b>	<b>Principal Emission★</b>
Ag-110m	gamma	Zr-93	beta	*Nb-94 (in activated metal - C-14, Ni-59, Ni-63)	gamma
Am-241	alpha	Sn-126	beta	+Kr-85	gamma
C-14	beta	Iso-U	alpha	#Cr-51	gamma
Cm-242	alpha	K-40	gamma	#Fe-59	gamma
Cm-243/244	alpha	Zn-65	gamma	#Nb-95	gamma
Co-57	gamma	Eu-154	gamma	#Zr-95	gamma
—	--	Eu-155	gamma	#Mo-99	gamma
Co-60	gamma	Eu-152	gamma	#I-131	gamma
Cs-134	gamma	Tl-208	gamma	#Xe-133	gamma
Cs-137	gamma	Bi-212	gamma	#Ba-140	gamma
Fe-55	ec	Pb-212	gamma	#La-140	gamma
H-3	beta	Bi-214	gamma	#Ce-141	gamma
Mn-54	gamma	Pb-214	gamma	#Sn-113	gamma
Ni-59	ec	Ra-226	gamma	#Sb-124	gamma
Ni-63	beta	Ac-228	gamma	#Ru-103	gamma
Pu-238	alpha	Pa-234m	gamma	#Co-58	gamma
Pu-239/240	alpha	Th-234	gamma		
Pu-241	beta	U-235	gamma		
Sb-125	gamma	Be-7	gamma		
Sr-90	beta	Ce-144	gamma		
*Tc-99	beta	Sb-126	gamma		
* +I-129	beta	Sn-126	gamma		

★ Analysis performed measuring this principal emission

\*for waste classification

#for Rx pwr operations (short lived) + in spent fuel

**Table 3-7**  
**10 CFR61 Sample Analysis Results (Typical)**

**These values are shown to present relative fractions of nuclides historically present.**

	RESIN	LIQUID	SMEAR	CAVITY DRAIN	UPENDER	#3 SG
	SAMPLE	FILTERS	ACTIVITY	DOWN FILTER	SMEAR	BOWL
	μCo/g 8/21/96	μCi/sample 9/4/96	μCi/sample 6/18/97	μCi/sample 7/23/96 ACTIVITY	μCi/sample 6/10/98 ACTIVITY	μCi/sample 3/28/98 SMEAR ACTIVITY
NUCLIDE						
H-3	2.00E-01		1.86E-02	1.40E-01		15500
C-14	8.51E-02					4270
Mn-54	8.01E-01		1.63E-03	1.00E-02	1.00E-03	1260
Fe-55	9.81E+00	7.49E-01	2.46E-01	2.58E-01	4.33E-02	160000
Co-57	2.07E-02		2.37E-04	4.79E-04		
Co-58	7.70E-02		4.15E-02			674
Co-60	9.68E+00	1.64E+00	4.48E-01	3.61E-01	1.14E-01	147000
Ni-59	1.04E-01					
Ni-63	1.42E+01	1.40E+00	3.34E-01	8.97E-02	3.86E-02	18700
Zn-65						
Sr-90	2.38E-01			2.74E-02		370
Zr-93						
Nb-94						
Tc-99						6920
Ag-110m			1.37E-03			
Sb-125	2.72E-01	2.62E-03	5.81E-03	1.61E-03	2.95E-03	2110
Sn-126						
I-129						
Cs-134	2.00E+01		5.54E-03			
Cs-137	3.72E+01	3.35E-03	8.06E-02	1.03E-02		
Ce-144				2.45E-03		
Eu-152						
Eu-154						
Eu-155						
U-234						
U-235						
U-238						
Pu-238	6.67E-04	1.53E-04	1.45E-05	1.83E-04	1.20E-05	6.9
Pu-239/240	2.79E-04	1.91E-04	2.24E-05	6.02E-04	1.53E-05	5.3
Pu-241	2.05E-02	1.65E-02	1.98E-03	2.32E-02	9.60E-04	315
Am-241	3.56E-04	2.71E-04	3.00E-05	2.77E-04	1.55E-05	3.4
Cm-242	1.64E-04			3.21E-06	6.10E-06	
Cm-243/244	4.53E-04	2.34E-04	1.19E-05		8.50E-06	1.8

**Table 3-8  
Deleted**

Although the total estimated radwaste volumes exceeds the 18,340 m<sup>3</sup> described in NUREG-0586 the associated impacts are bounded by those addressed in the FGEIS as discussed in detail in section 8.7.

Materials removed and/or generated during the demolition process will be disposed of based upon the origin of the material and the radiological survey findings prior to or after demolition.

**Table 3-9  
Deleted**

Table 3-10 below describes the approach to handling building materials for regulatory release.

<b>Table 3-10 Approach to Handling of Building Materials for Regulatory Release</b>		
<b>No.</b>	<b>Type of building material</b>	<b>Approach</b>
1	Areas with low contamination potential	Free-release in accordance with procedures
2	Concrete with medium to high surface contamination potential (at elevations above - 3 feet below grade)	Ship offsite for disposal at Energy Solutions or Barnwell or an appropriate disposal facility
	Concrete with medium to high surface contamination potential (at elevations below - 3 feet below grade)	Remediate to acceptance criteria levels and leave in place, with removed material disposal at Energy Solutions or Barnwell
3	Contaminated metals removed	Ship to processor or for disposal at Energy Solutions or Barnwell
	Non-contaminated metals removed	Ship to processor for scrap or disposal

4	Built-up tar roofing, inner layer of siding (with actual or potential contamination)	Process at LLW treatment facility or directly dispose at Energy Solutions
	“Clean” tar roofing, siding	Ship to a processor or disposal
5	Outer layer of siding (Galbestos)	Surface release survey; send to asbestos landfill
6	Refueling cavity and spent fuel pool liners	<u>Process at LLW treatment facility</u>

### 3.5.3 Occupational Exposure

The estimated total nuclear worker exposure during decommissioning of the plant was estimated to be 946 person-rem. The total exposure associated with decommissioning of the ISFSI is not anticipated to be significant. The total combined exposure for decommissioning the plant and the ISFSI is expected to be below the 1215 person-rem found acceptable for decommissioning in the reference PWR NUREG-0586 Table 4.3-2.

**Table 3-11**  
**Deleted**

### 3.5.4 Public Exposure

Continued application of Maine Yankee’s Radiation Protection Program, Waste Management Plan, Radiological Effluents Controls Program and Radiological Environmental Monitoring Program assures public protection in accordance with 10 CFR 20. Details for remediation are provided in Section 4 of this LTP. LTP Section 8 contains an evaluation of estimated public exposure as a result of decommissioning activities including the transportation of radioactive waste.

### 3.5.5 Expected Radiological Conditions

The ISFSI storage pads and Vertical Concrete Casks are assumed to contain activation products.

Surface abrasive or surface removal remediation techniques may generate airborne radioactivity. Airborne activity will be controlled within the requirements of 10 CFR Part 20 and measured using standard processes and procedures existing within the radiation protection program. These processes and procedures have proven successful for controlling decontamination and demolition activities in the past while protecting the health and safety of the workers and the public.

Maine Yankee segmented the reactor vessel internals and loaded resulting GTCC waste into NAC UMS casks for storage at the ISFSI. This segmentation process used an abrasive water jet. Special precautions were taken to capture the residue (SWARF) resulting from this segmentation.

#### 3.5.6 Contamination Control

A systematic approach to controlling areas will be established. Upon commencement of the FSS for survey areas where there is a potential for re-contamination, implementation of one or more of the following control measures will be required:

- a. Personnel training
- b. Installation of barriers to control access to surveyed areas
- c. Installation of barriers to prevent the migration of contamination from adjacent overhead areas
- d. Installation of postings requiring personnel to perform contamination monitoring prior to surveyed area access
- e. Locking entrances to surveyed areas of the facility
- f. Installation of tamper-evident labels
- g. Upon completion of FSS, the area is placed under periodic routine survey by Radiation Protection to ensure no re-contamination occurs. If re-contamination is identified, an investigation will be initiated that would result in corrective actions up to and including re-performance of the FSS on that area.

During the D&D activities, measures will be maintained and/or established to control and monitor radwaste effluents. No radwaste effluents are anticipated to occur during the period of storage of spent fuel and GTCC waste at the ISFSI or decommissioning of the ISFSI.

#### Airborne Controls

No airborne effluents are anticipated to occur during the period of storage of spent fuel and GTCC waste at the ISFSI or decommissioning of the ISFSI.

When applicable during demolition engineering controls such as misting will be applied to concrete surfaces. Where practical for ALARA purposes, temporary shielding is used during decommissioning activities.

#### Liquid/Particle Control

Work activities are planned to minimize the spread of contamination. To minimize the potential for spread of contamination, the following considerations will continue to be addressed when planning decommissioning work activities.

- a. Covering of openings in contaminated components to confine internal contamination;
- b. D&D of SSCs by decontamination in place, removal and decontamination, or removal and disposal.

### 3.6 Coordination with Other Regulatory Agencies

The decommissioning and termination of Maine Yankee's Part 50 license involves, in addition to the NRC, coordination with a number of federal, state and local agencies as well as several advisory groups. This section outlines the broad responsibilities of those groups and also addresses specific environmental issues raised in the FGEIS in the context of the Maine Yankee site.

#### 3.6.1 Regulatory Agencies

The following federal, state and local agencies have some level of involvement in Maine Yankee's decommissioning. Some have direct approval authority over site activities while others serve in an advisory capacity to other agencies. Their primary functions, programs, and regulatory authority are described below.

- a. US Environmental Protection Agency (EPA) - EPA has been engaged in discussions with various stakeholders about the Maine Yankee decommissioning process. The EPA is supporting the Maine Yankee decommissioning project in several areas. The EPA is enabled by Resource Conservation and Recovery Act (RCRA) to administer closure of facilities that were hazardous waste generators. Since the State of Maine Department of Environmental Protection (MDEP) has been delegated authority to administer the RCRA program in Maine, EPA is serving in a technical support role for the Maine Yankee site closure. EPA is expected to review all major closure related documents and advise MDEP on their adequacy.



The EPA also is responsible for the Toxic Substances Control Act (TSCA) which serves as the primary means by which the use and disposal of PCBs and PCB-containing materials are controlled. PCBs were identified above the TSCA limits of 50 parts per million (ppm) in electrical cable sheathing and, in limited areas, painted structural steel and painted concrete surfaces.

- b. US Department of Transportation ( DOT) - The DOT regulates the packaging, labeling and shipment of waste materials offered for interstate commerce. Waste materials that are expected to be shipped from Maine Yankee during decommissioning that are regulated by the DOT include radiological wastes, mixed waste, and hazardous waste.
- c. US Coast Guard - The Coast Guard has authority to control vessel traffic in the navigable waterways of the US. Barge shipment of large components will be coordinated with the Coast Guard to ensure that all applicable requirements for securing loads and notifying the public are met.
- d. US Department of Energy (DOE) - The DOE has a contractual obligation to take receipt and dispose of Maine Yankee's GTCC waste and spent nuclear fuel. This includes removing the material from the site.
- e. Maine Department of Environmental Protection (MDEP) - The MDEP is the lead state agency responsible to prevent, abate and control the pollution of the air, water and land and prevent diminution of the natural environment of the state. The MDEP has authority in a variety of statutes and accomplishes its charge through a number of regulations. The MDEP regulates solid and hazardous waste activities, development activities at Maine Yankee through the Site Location of Development Law, industrial discharges, air emissions, and activities affecting significant natural resources including coastal and freshwater wetlands. These aspects are discussed in more detail in Section 8.6.
- f. Maine Department of Human Services - The Department of Human Services through the Division of Health Engineering (DHE) has responsibility for radiological programs within the state. DHE also sponsors the two State Nuclear Inspectors that monitor activities at Maine Yankee.
- g. Maine Department of Inland Fisheries and Wildlife (IF&W) - IF&W does not directly regulate activities at Maine Yankee. IF&W does however provide technical support to the MDEP for permitting activities relating to development projects and projects that may affect significant natural

resources. IF&W is also responsible for the Maine threatened and endangered species protection program.

- h. Maine Department of Marine Resources (DMR) - DMR does not directly regulate activities at Maine Yankee. However DMR does provides technical support to MDEP on projects involving potential impacts to coastal wetlands.
- i. Maine Department of Transportation (MDOT) - MDOT has permitting authority for new development projects generating over 100 passenger car equivalent trips in the peak hour. It is not anticipated that MDOT will have active involvement in decommissioning activities.
- j. Maine Historic Preservation Commission - Maine Yankee has coordinated with this organization for the preservation of the two identified archaeological sites on Maine Yankee property. The specific location of archaeological sites is not provided to ensure their integrity is protected.
- k. Town of Wiscasset (Town) - The Town has permitting authority over new development projects such as the Independent Spent Fuel Storage Installation (ISFSI). The Town also has permitting authority over major earthwork projects. It is expected that final site grading will trigger Town review and approval requirements.
- l. The Maine Turnpike Authority- has a long standing agreement that placarded shipments of LLW will only travel on the Turnpike during daylight hours.
- m. The Maine State Police- are given a courtesy call before each LLW shipment leaves the site. This is not an official requirement.

### 3.6.2 Advisory and Community Entities

- a. The State Nuclear Safety Advisor responsibilities include advising the Governor and legislature on nuclear power issues, specifically transport and storage of nuclear waste at Maine Yankee. The Advisor also consults with relevant federal agencies and coordinates the activities of state agencies with respect to decommissioning. Another duty is to keep abreast of related activities in other states and to advise the Governor and legislature on such activities. In addition to making these recommendations and updates to the Governor, the Advisor prepares an annual report.

- b. The Maine Yankee Community Advisory Panel (CAP) was established in 1997 to enhance opportunities for public involvement in the decommissioning process of Maine Yankee. The CAP represents the community. By thoroughly reviewing the decommissioning process, the CAP is in a position to advise Maine Yankee on key issues of concern to the regional community.
- c. Friends of the Coast Opposing Nuclear Pollution is a local environmental organization founded in 1995. Friends of the Coast participates regularly in stakeholder discussions on the full range of decommissioning issues and has a seat on the Maine Yankee CAP.

### 3.6.3 Environmental and Regulatory Issues

Section 8.6 of the LTP provides a detailed discussion of how non-radiological environmental and regulatory issues associated with decommissioning are being addressed with the cognizant state and federal agencies having jurisdiction over those issues.

## 3.7 References

- 3.7.1 NUREG-1700, "Standard Review Plan for Evaluating Nuclear Power Reactor License Termination Plans"
- 3.7.2 NRC Regulatory Guide 1.179, "Standard Format and Content of License Termination Plans for Nuclear Power Reactors" (January 1999)
- 3.7.3 Post Shutdown Decommissioning Activities Report
- 3.7.4 "Characterization Survey Report for the Maine Yankee Atomic Power Plant", Volumes 1-8, 1998 GTS Duratek
- 3.7.5 "Site History Report," Stone and Webster Environmental Technology and Services (November 1999), transmitted via James T. Kilbreth letter to Joan Jones, State of Maine, dated November 16, 1999
- 3.7.6 Kim Tripp, US Fish and Wildlife Services, letter to David Asherman, dated July 21, 1999, regarding federally listed species.
- 3.7.7 NRC letter to Maine Yankee, dated July 30, 2002, Issuance of Amendment No. 167, license amendment approving partial release of site lands

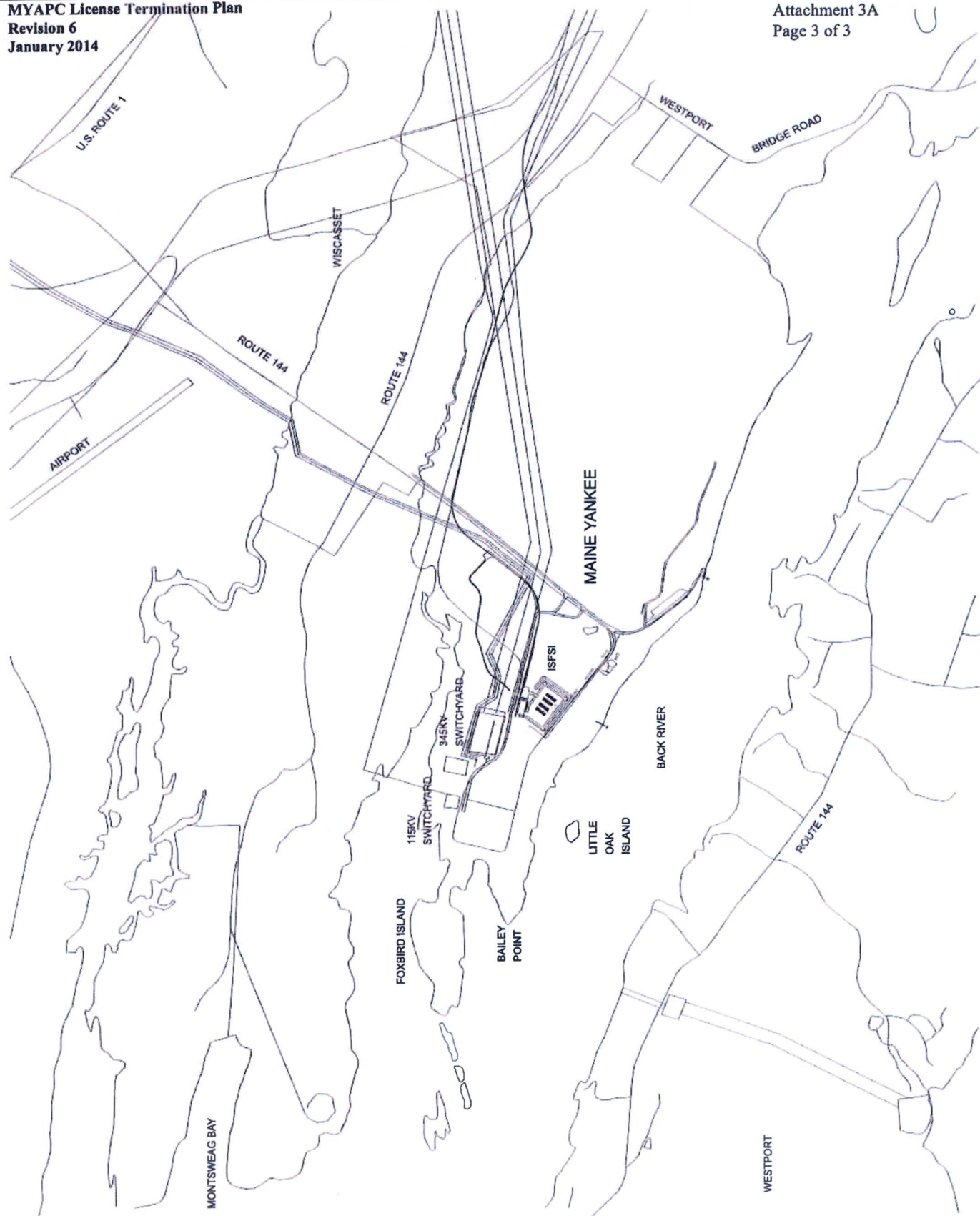
- 3.7.8 Letter from D. Gillen (NRC) to J. Niles (MYAPCO), Issuance of Amendment No. 172 to Facility Operating License No. DPR-36 - Maine Yankee Atomic Power Station (TAC No. M8000), dated September 30, 2005

### **ATTACHMENT 3A**

#### **Drawing Associated with Specific Decommissioning Tasks**

The drawing is provided “For Information Only” to support the reader’s understanding and correlation of decommissioning tasks and physical locations involved in the subject tasks.

TABLE 3 A-1 DECOMMISSIONING AREAS		
Figure Number	Figure Title	Areas
Figures 3-1 through 3-29	Deleted following removal of associated areas from the 10 CFR 50 License	
Figure 3-30	Final Site Configuration	



**MYAPC License Termination Plan**  
**Revision 6**  
**January 2014**

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**MAINE YANKEE**  
**LTP SECTION 4**  
**SITE REMEDIATION PLAN**



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### ATTACHMENT 4A

Calculation of ALARA Residual Radioactivity Levels

### ATTACHMENT 4B

Unit Cost Values

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## **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.

As of September 30, 2005, the only decommissioning activities that remain are those associated with the ISFSI. The information included in this section of the LTP includes historical information regarding the decommissioning of the Maine Yankee Nuclear Plant that will be maintained in its current form. This information will be reviewed, and revised as necessary, at the time of initiating the decommissioning activities for the ISFSI and associated land areas to ensure that appropriate information is available for the implementation of final status survey activities for the ISFSI and termination of the Part 50 License for the Maine Yankee site.

### **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. 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<sup>2</sup> 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 use 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

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.

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 was 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. In addition, the NRC released those areas from the control of the 10 CFR 50 License. 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.

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. 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, 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<sup>2</sup>. This is based on a survey unit with a 100 m<sup>2</sup> floor area with contaminated walls to a height of 2 meters. ALARA cost analyses are based on an assumption that only the 100 m<sup>2</sup> 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 remediation. 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 anticipated regarding the ISFSI storage pads and Vertical Concrete Casks. The decommissioning cost estimate assumes that the materials that comprise these structures will be disposed of as low-level radioactive waste.

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<sup>2</sup> 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<sup>3</sup> 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<sup>2</sup>) 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<sup>3</sup> 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  $4.96\text{E}+04 \text{ ft}^3$  ( $1403.0 \text{ m}^3$ ) 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 <sup>a</sup>	Remarks
Pressure Washing and Vacuuming	\$19.32/m <sup>2</sup>	Unit cost factors provided in Attachment B
Wiping/Washing <sup>a</sup>	\$48.59/m <sup>2</sup>	Unit cost factors provided in Attachment B
Concrete Scabbling <sup>b</sup> (Upper Bound)	\$106.23/m <sup>2</sup>	Unit cost factors provided in Attachment B. Needle gun activities are included with scabbling
Concrete Scabbling (Lower Bound)	\$91.49/m <sup>2</sup>	Unit cost factors provided in Attachment B. Needle gun activities are included with scabbling
Grit Blasting Surfaces (Upper Bound)	\$113.18/m <sup>2</sup>	Unit cost factors provided in Attachment B
Grit Blasting Surfaces (Upper Bound)	\$87.80/m <sup>2</sup>	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 <sup>3</sup>	Unit cost factors provided in Attachment B

<sup>a</sup>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

<sup>b</sup>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.

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

Where: B<sub>AD</sub> is the benefit of averted dose

Variables are as described in NUREG-1727, Table D2. The detailed description of the calculation of the B<sub>AD</sub> 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<sub>w</sub> 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<sub>w</sub> value.

<b>Table 4-2</b>		
<b>ALARA Evaluation Conc/DCGL<sub>w</sub> Results</b>		
<b>Remediation Action</b>	<b>Basement Fill</b>	<b>Building Occupancy</b>
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 <sup>a</sup>	---
Soil Excavation	733.9 <sup>b</sup>	---

<sup>a</sup>Grit blasting of embedded piping is not evaluated for Building Occupancy

<sup>b</sup>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).

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

Where:

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

$Cost_T$  = 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 ( $\text{yr}^{-1}$ )
- $\lambda$  = Radiological decay constant for the radionuclide ( $\text{yr}^{-1}$ )
- $N$  = 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:

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

$$= \frac{Cost_r}{(\$2000)(P_D)(0.025)(F)(A)} \left[ \frac{r + \lambda}{1} \right]$$

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

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

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:

$$Df_i = \text{Dose Fraction}_{\text{basement fill}} = \frac{(nf_i)(\text{Unitized Dose Factor}_i)}{\sum_i^n (nf_i)(\text{Unitized Dose Factor}_i)}$$

or, Building Occupancy;

$$Df_i = \text{Dose Fraction}_{\text{building occupancy}} = \frac{\frac{nf_i}{\text{Screening Value}_i}}{\sum_i^n \frac{nf_i}{\text{Screening Value}_i}}$$

And,

$nf_i$  = nuclide fraction of the mixture radionuclide

Unitized Dose Factor<sub>*i*</sub> (basement fill) = nuclide specific mrem/y per dpm/100 cm<sup>2</sup> (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<sub>*i*</sub> (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:

$C_{WD} = V_A \times C_V$

$V_A$  Is the volume of waste produced, remediated in units of m<sup>3</sup> and;

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

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

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

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

$F_W$  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:

$$C_{TF} = \$3,000,000 \times V_A \times [(F_T \times D_T)/V_{ship}]$$

$F_T$  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 (Energy Solutions), 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  $m^3$ .

$$C_{WDose} = \$2,000 \times D_R \times T:$$

$C_{WDose}$  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  $yr^{-1}$

$\lambda$  = 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<sup>2</sup> since the resident farmer is the critical group. The area remediated is the assumed model area of 4182 m<sup>2</sup>. Note that reducing this area size would reduce dose proportionally. For the Building Occupancy model the occupancy area is a 100 m<sup>2</sup> floor in a standing building; the remediation area is also assumed to be 100 m<sup>2</sup>.

#### 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<sub>w</sub> 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<sub>w</sub> 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<sub>w</sub> result is 312.6.

##### Washing and Wiping (Building Occupancy Model)

The building occupancy model as stated is based on a 100 m<sup>2</sup> area. The removal fraction is 0.20. The ALARA Evaluation results shows the Conc/DCGL<sub>w</sub> 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<sub>w</sub> 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<sup>2</sup>. The results of the evaluation show the action is still ALARA without remediation actions. The ALARA Evaluation shows the Conc/DCGL<sub>w</sub> 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<sub>w</sub> 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<sub>w</sub> 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<sub>w</sub> 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<sup>3</sup> or about 94 percent of what would be removed from an area 10,000 m<sup>2</sup> by 0.15 m deep. The ALARA Evaluation results show the Conc/DCGL<sub>w</sub> 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													
<b>Pressure Washing Remediation Activity</b> <b>Condition (removal fraction "F"@ 0.25)</b> A=10k m <sup>2</sup> , r = 0.03, N = 1000, P <sub>D</sub> = 0.0004 PWAD4prwfill.wb3) 4/26/01													
<b>ALARA EVALUATION</b>								<b>Remediation Cost and Area</b> <table border="1" style="margin: auto;"> <tr> <th>Unit Cost/M<sup>2</sup></th> <th>Actual Area M<sup>2</sup></th> </tr> <tr> <td>\$19.32</td> <td>4182.0</td> </tr> </table>		Unit Cost/M <sup>2</sup>	Actual Area M <sup>2</sup>	\$19.32	4182.0
Unit Cost/M <sup>2</sup>	Actual Area M <sup>2</sup>												
\$19.32	4182.0												
Enter fraction of activity removed by remedial action ==>								0.25					
Enter Occupancy Area in m <sup>2</sup> ==>								10,000					
Enter total cost (C <sub>T</sub> , in dollars) of Action(s) ==>								\$80,796					

Basement Fill Scenario													
nuclide	halflife <sup>a</sup> (yrs)	λ (yrs <sup>-1</sup> ) <sup>b</sup>	(r + λ)	(r + λ)N	e <sup>-(r + λ)N</sup>	[1-e <sup>-(r + λ)N</sup> ]	[1-e <sup>-(r + λ)N</sup> ]/(r + λ)	nuclide	BAD	Nuclide Fraction	Unitized Dose <sup>c</sup> Factor (UDF)	n/f (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
<b>Mixture Total: Benefit of Averted Dose BAD ==&gt;</b>								\$812.56		1.00E+00			
<b>Conc/DCGLw ==&gt;</b>								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/t<sub>1/2</sub>; c: From Table 6-2, unitized annual dose rate for contaminated concrete per dpm/100 centimeters squared

Table A-3

Building Occupancy Scenario													
<b>Pressure Washing Remediation Activity</b> <b>Condition (removal fraction "F"@ 0.25)</b> A=100 m <sup>2</sup> , r = 0.07, N = 70, P <sub>D</sub> = 0.09 PWAD4prwbo.wb3) 4/26/01													
<b>ALARA EVALUATION</b>								<b>Remediation Cost and Area</b> <table border="1" style="margin: auto;"> <tr> <th>Unit Cost/M<sup>2</sup></th> <th>Actual Area M<sup>2</sup></th> </tr> <tr> <td>\$19.32</td> <td>100.0</td> </tr> </table>		Unit Cost/M <sup>2</sup>	Actual Area M <sup>2</sup>	\$19.32	100.0
Unit Cost/M <sup>2</sup>	Actual Area M <sup>2</sup>												
\$19.32	100.0												
Enter fraction of activity removed by remedial action ==>								0.25					
Enter Occupancy Area in m <sup>2</sup> ==>								100					
Enter total cost (C <sub>T</sub> , in dollars) of Action(s) ==>								\$1,932					

Building Occupancy Scenario													
nuclide	halflife <sup>a</sup> (yrs)	λ (yrs <sup>-1</sup> ) <sup>b</sup>	(r + λ)	(r + λ)N	e <sup>-(r + λ)N</sup>	[1-e <sup>-(r + λ)N</sup> ]	[1-e <sup>-(r + λ)N</sup> ]/(r + λ)	nuclide	BAD	Nuclide Fraction	Screening <sup>c</sup> Value (SC)	n/f SC	SC/sum(n/f SC)
H-3	1.236E+01	5.607E-02	1.261E-01	8.825E+00	1.470E-04	9.998E-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
<b>Mixture Total: Benefit of Averted Dose BAD: \$1,012.13</b>								1.00E+00					
<b>Conc/DCGLw ==&gt;</b>								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/t<sub>1/2</sub>; c: From NUREG-1727 Table C2.2, dpm/100 centimeters squared

Table A-4

Basement Fill Scenario													
<b>Washing and Wiping Remediation Activity</b> <b>Condition (removal fraction "F"@ 0.25)</b> A=10k m <sup>2</sup> , r = 0.03, N =1000, P <sub>D</sub> = 0.0004 PWAD4wwfill.wb3) 4/26/01													
<b>ALARA EVALUATION</b>								<b>Remediation Cost and Area</b> <table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td style="width:50%;">Unit Cost/M<sup>2</sup></td> <td style="width:50%;">Actual Area M<sup>2</sup></td> </tr> <tr> <td style="text-align: center;">\$48.59</td> <td style="text-align: center;">4182.0</td> </tr> </table>		Unit Cost/M <sup>2</sup>	Actual Area M <sup>2</sup>	\$48.59	4182.0
Unit Cost/M <sup>2</sup>	Actual Area M <sup>2</sup>												
\$48.59	4182.0												
Enter fraction of activity removed by remedial action ==>								0.2					
Enter Occupancy Area in m <sup>2</sup> ==>								10,000					
Enter total cost (C <sub>T</sub> , in dollars) of Action(s) ==>								\$203,203					

Basement Fill Scenario															
nuclide	halflife <sup>a</sup> (yrs)	λ (yrs <sup>-1</sup> ) <sup>b</sup>	(r + λ)	(r + λ)N	e <sup>-(r + λ)N</sup>	[1-e <sup>-(r + λ)N</sup> ]	[1-e <sup>-(r + λ)N</sup> ]/(r + λ)	nuclide	Bad	Nuclide Fraction	Unitized Dose <sup>c</sup> Factor (UDF)	n/f 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		
a: Table of the Isotopes, Seventh Edition, Lederer et al. 1978; b: Lambda = 0.69315/t <sub>1/2</sub> ; c: From Table 6-2, unitized annual dose rate for contaminated concrete per dpm/100 centimeters squared								<b>Mixture Total: Benefit of Averted Dose B<sub>AD</sub> ==&gt;</b>		1.00E+00		1.00E+00			
								<b>Conc/DCGL<sub>w</sub> ==&gt;</b>		312.60		<b>Sum Check</b>		Sum 1.90E-05 1.00E+00	

Table A-5

Building Occupancy Scenario													
<b>Washing and Wiping Remediation Activity</b> <b>Condition (removal fraction "F"@ 0.25)</b> A=100 m <sup>2</sup> , r =0.07, N=70, P <sub>D</sub> = 0.09 PWAD4wwbo.wb3) 04/26/01													
<b>ALARA EVALUATION</b>								<b>Remediation Cost and Area</b> <table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td style="width:50%;">Unit Cost/M<sup>2</sup></td> <td style="width:50%;">Actual Area M<sup>2</sup></td> </tr> <tr> <td style="text-align: center;">\$48.59</td> <td style="text-align: center;">100.0</td> </tr> </table>		Unit Cost/M <sup>2</sup>	Actual Area M <sup>2</sup>	\$48.59	100.0
Unit Cost/M <sup>2</sup>	Actual Area M <sup>2</sup>												
\$48.59	100.0												
Enter fraction of activity removed by remedial action ==>								0.2					
Enter Occupancy Area in m <sup>2</sup> ==>								100					
Enter total cost (C <sub>T</sub> , in dollars) of Action(s) ==>								\$4,859					

Building Occupancy Scenario															
nuclide	halflife <sup>a</sup> (yrs)	λ (yrs <sup>-1</sup> ) <sup>b</sup>	(r + λ)	(r + λ)N	e <sup>-(r + λ)N</sup>	[1-e <sup>-(r + λ)N</sup> ]	[1-e <sup>-(r + λ)N</sup> ]/(r + λ)	nuclide	Bad	Nuclide Fraction	Screening <sup>c</sup> Value (SC)	n/f SC	SC/sum(n/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		
a: Table of the Isotopes, Seventh Edition, Lederer et al. 1978; b: Lambda = 0.69315/t <sub>1/2</sub> ; c: From NUREG-1727 Table C2.2, dpm/100 centimeters squared								<b>Mixture Total: Benefit of Averted Dose B<sub>AD</sub> =</b>		1.00E+00		1.00E+00			
								<b>Conc/DCGL<sub>w</sub> ==&gt;</b>		6.00		<b>Sum Check</b>		Sum 2.88E-05 1.00E+00	

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<sup>2</sup>, 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<sup>2</sup> ==>

10,000

Enter total cost (C<sub>T</sub>, in dollars) of Action(s) ==>

\$444,254

Remediation Cost and Area

Unit Cost/M <sup>2</sup>	Actual Area M <sup>2</sup>
\$106.23	4182.0

Basement Fill Scenario

nuclide	halflife <sup>a</sup> (yrs)	$\lambda$ (yrs <sup>-1</sup> ) <sup>b</sup>	(r + $\lambda$ )	(r + $\lambda$ )N	e <sup>-(r + <math>\lambda</math>)N</sup>	[1-e <sup>-(r + <math>\lambda</math>)N</sup> ]	[1-e <sup>-(r + <math>\lambda</math>)N</sup> ]/(r + $\lambda$ )	nuclide	Nuclide B <sub>AD</sub>	Nuclide Fraction	Unkized Dose <sup>c</sup> Factor (UDF)	n/f (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 <sub>AD</sub> ==>									\$3,087.72	1.00E+00			
Conc/DCGL <sub>w</sub> ==>									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/t<sub>1/2</sub>;

c: From Table 6-2,unkized 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<sup>2</sup>, 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<sup>2</sup> ==>

10,000

Enter total cost (C<sub>T</sub>, in dollars) of Action(s) ==>

\$382,611

Remediation Cost and Area

Unit Cost/M <sup>2</sup>	Actual Area M <sup>2</sup>
\$91.49	4182.0

Basement Fill Scenario

nuclide	halflife <sup>a</sup> (yrs)	$\lambda$ (yrs <sup>-1</sup> ) <sup>b</sup>	(r + $\lambda$ )	(r + $\lambda$ )N	e <sup>-(r + <math>\lambda</math>)N</sup>	[1-e <sup>-(r + <math>\lambda</math>)N</sup> ]	[1-e <sup>-(r + <math>\lambda</math>)N</sup> ]/(r + $\lambda$ )	nuclide	Nuclide B <sub>AD</sub>	Nuclide Fraction	Unkized Dose <sup>c</sup> Factor (UDF)	n/f (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 <sub>AD</sub> ==>									\$3,087.72	1.00E+00			
Conc/DCGL <sub>w</sub> ==>									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/t<sub>1/2</sub>;

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

Table A-8

Building Occupancy Scenario

Scabbling Remediation Activity

Bounding Condition (remove 0.25 inches of concrete surface)

A=100 m<sup>2</sup>, r=0.07, N=70, P<sub>D</sub> = 0.09

PWAD4scabo.wb3)

4/26/01

ALARA EVALUATION

Enter fraction of activity removed by remedial action ==>

0.95

Enter Occupancy Area in m<sup>2</sup> ==>

100

Enter total cost (C<sub>T</sub>, in dollars) of Action(s) ==>

\$10,623

Remediation Cost and Area

Unit Cost/M <sup>2</sup>	Actual Area M <sup>2</sup>
\$106.23	100.0

Building Occupancy Scenario

nuclide	half-life <sup>a</sup> (yrs)	λ (yrs <sup>-1</sup> ) <sup>b</sup>	(r + λ)	(r + λ)N	e <sup>-(r + λ)N</sup>	[1 - e <sup>-(r + λ)N</sup> ]	[1 - e <sup>-(r + λ)N</sup> ]/(r + λ)	nuclide	Nuclide Bad	Nuclide Fraction	Screening <sup>c</sup> Value (SC)	n/SC	SC/sum[n/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

a: Table of the Isotopes, Seventh Edition, Lederer et al. 1978; b: Lambda = 0.69315/N<sub>1/2</sub>;

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

Total: Benefit of Averted Dose B<sub>AD</sub> ==>

\$3,846.09

Conc/DCGL<sub>w</sub> ==>

2.76

1.00E+00				
Sum Check	Sum	2.88E-05	1.00E+00	

Table A-9

Building Occupancy Scenario

Scabbling Remediation Activity

Bounding Condition (remove 0.125 inches of concrete surface)

A=100 m<sup>2</sup>, r=0.07, N=70, P<sub>D</sub> = 0.09

PWAD4scabo.wb3)

4/26/01

ALARA EVALUATION

Enter fraction of activity removed by remedial action ==>

0.95

Enter Occupancy Area in m<sup>2</sup> ==>

100

Enter total cost (C<sub>T</sub>, in dollars) of Action(s) ==>

\$9,149

Remediation Cost and Area

Unit Cost/M <sup>2</sup>	Actual Area M <sup>2</sup>
\$91.49	100.0

Building Occupancy Scenario

nuclide	half-life <sup>a</sup> (yrs)	λ (yrs <sup>-1</sup> ) <sup>b</sup>	(r + λ)	(r + λ)N	e <sup>-(r + λ)N</sup>	[1 - e <sup>-(r + λ)N</sup> ]	[1 - e <sup>-(r + λ)N</sup> ]/(r + λ)	nuclide	Nuclide Bad	Nuclide Fraction	Screening <sup>c</sup> Value (SC)	n/SC	SC/sum[n/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

a: Table of the Isotopes, Seventh Edition, Lederer et al. 1978; b: Lambda = 0.69315/N<sub>1/2</sub>;

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

Mixture Total: Benefit of Averted Dose B<sub>AD</sub> =

\$3,846.09

Conc/DCGL<sub>w</sub> ==>

2.38

1.00E+00				
Sum Check	Sum	2.88E-05	1.00E+00	



**Table A-10**

## Surface Grit Blasting Remediation Activity

## ALARA EVALUATION

Enter fraction of activity removed by remedial action = 0.95

### Remediation Cost and Area

Unit Cost/M <sup>2</sup>	Actual Area M <sup>2</sup>
\$113.18	4182.0

Enter Occupancy Area in m<sup>2</sup> ===== 10,000

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

nuclide	half-life <sup>a</sup> (yrs)	$\lambda$ (yrs <sup>-1</sup> ) <sup>b</sup>	(r + $\lambda$ )	(r + $\lambda$ )N	e-(r + $\lambda$ )N	$[1-e^{-(r+\lambda)N}]$	$[1-e-(r+\lambda)N]/(r+\lambda)$	nuclide	$B_{\alpha}$	Fraction	Factor (UDF)	nff (UDF)	UDF/ Sum (UDF)
H-3	1.236E+01	5.607E-02	<b>8.607E-02</b>	8.607E+01	4.167E-38	1.000E+00	<b>1.162E+01</b>	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	<b>2.882E-01</b>	2.882E+02	7.166E-126	1.000E+00	<b>3.470E+00</b>	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	<b>9.645E-01</b>	9.645E+02	0.000E+00	1.000E+00	<b>1.037E+00</b>	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	<b>1.615E-01</b>	1.615E+02	7.071E-71	1.000E+00	<b>6.191E+00</b>	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	<b>3.692E-02</b>	3.692E+01	9.202E-17	1.000E+00	<b>2.708E+01</b>	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	<b>5.405E-02</b>	5.405E+01	3.357E-24	1.000E+00	<b>1.850E+01</b>	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	<b>3.662E-01</b>	3.662E+02	9.577E-160	1.000E+00	<b>2.731E+00</b>	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	<b>5.297E-02</b>	5.297E+01	9.878E-24	1.000E+00	<b>1.888E+01</b>	Cs-137	2.347E+03	5.50E-01	2.26E-05	1.24E-05	6.54E-01

Mixture Total: Benefit of Averted Dose BAD:		\$3.087.72
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c: From Table 8-2, unitized annual dose rate for contaminated concrete per dpm/100 centimeters squared

Conc/DCGL <sub>w</sub> =====	153.29
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1.00E+00			
Sum Check	Sum	1.90E-05	1.00E+00

**Table A-11**

### Surface Grit Blasting Remediation Activity

## ALARA EVALUATION

Enter fraction of activity removed by remedial action = 0.95

### Remediation Cost and Area

Unit Cost/M <sup>2</sup>	Actual Area M <sup>2</sup>
\$87.80	4182.0

Enter Occupancy Area in m<sup>2</sup> =====> 10,000

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

nuclide	halflife <sup>a</sup> (yrs)	$\lambda$ (yrs <sup>-1</sup> ) <sup>b</sup>	( $r + \lambda$ )	( $r + \lambda$ )N	e-( $r + \lambda$ )N	$[1-e^{-(r+\lambda)N}]$	$[1-e^{-(r+\lambda)N}]/(r+\lambda)$	nuclide	B <sub>0N</sub>	Fraction	Factor (UDF)	n/(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 BAD: \$3,087.72**

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

Conc/DCGLw	=====	118.92
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1.00E+00			
Sum Check	Sum	1.90E-05	1.00E+00

Table A-12

Building Occupancy

**Surface Grit Blasting Remediation Activity**  
**Using upper bound cost contingency**  
PWAD4surgitbo.wb3)  
A=100 m<sup>2</sup>, r=0.07, N=70, Pd = 0.09  
4/26/01

**ALARA EVALUATION**

Enter fraction of activity removed by remedial action ==>

Enter Occupancy Area in m<sup>2</sup> ==>

Enter total cost (C<sub>T</sub>, in dollars) of Action(s) ==>

Remediation Cost and Area	
Unit Cost/M <sup>2</sup>	Actual Area M <sup>2</sup>
\$113.18	100.0

Building Occupancy									
nuclide	half-life <sup>a</sup> (yrs)	λ (yrs <sup>-1</sup> ) <sup>b</sup>	(r + λ)	(r + λ)N	e <sup>-(r + λ)N</sup>	[1-e <sup>-(r + λ)N</sup> ]	[1-e <sup>-(r + λ)N</sup> ]/(r + λ)	nuclide	
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	
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	
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	
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	
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	
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	
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	
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	
Mixture Total: Benefit of Averted Dose B <sub>AD</sub> ==>								\$3,846.09	1.00E+00
Conc/DCGL <sub>w</sub> ==>								2.94	Sum Check
								Sum	2.88E-05
								Sum	1.00E+00

a: Table of the Isotopes, Seventh Edition, Lederer et al. 1978; b: Lambda = 0.69315/t<sub>1/2</sub>;  
c: From NUREG-1727 Table C2.2, dpm/100 centimeters squared

Table A-13

**Surface Grit Blasting Remediation Activity**  
**Using lower bound cost contingency**  
PWAD4surgitbo.wb3)  
A=100 m<sup>2</sup>, r=0.07, N=70, Pd = 0.09  
4/26/01

**ALARA EVALUATION**

Enter fraction of activity removed by remedial action ==>

Enter Occupancy Area in m<sup>2</sup> ==>

Enter total cost (C<sub>T</sub>, in dollars) of Action(s) ==>

Remediation Cost and Area	
Unit Cost/M <sup>2</sup>	Actual Area M <sup>2</sup>
\$87.80	100.0

Building Occupancy									
nuclide	half-life <sup>a</sup> (yrs)	λ (yrs <sup>-1</sup> ) <sup>b</sup>	(r + λ)	(r + λ)N	e <sup>-(r + λ)N</sup>	[1-e <sup>-(r + λ)N</sup> ]	[1-e <sup>-(r + λ)N</sup> ]/(r + λ)	nuclide	
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	
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	
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	
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	
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	
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	
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	
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	
Mixture Total: Benefit of Averted Dose B <sub>AD</sub> ==>								\$3,846.09	1.00E+00
Conc/DCGL <sub>w</sub> ==>								2.28	Sum Check
								Sum	2.88E-05
								Sum	1.00E+00

a: Table of the Isotopes, Seventh Edition, Lederer et al. 1978; b: Lambda = 0.69315/t<sub>1/2</sub>;  
c: From NUREG-1727 Table C2.2, dpm/100 centimeters squared

Table A-14

**Basement Fill Scenario**

**Embedded Piping Remediation Activity**  
PWAD4embfill.wb3)  
A=10k m<sup>2</sup>, r=0.03, N=1000, Pd = 0.0004  
Unit cost are in Linear Feet  
4/26/01

**ALARA EVALUATION**

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

Enter Occupancy Area in m<sup>2</sup> ==> 10,000

Enter total cost (C<sub>T</sub>, 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	half-life <sup>a</sup> (yrs)	$\lambda$ (yrs <sup>-1</sup> ) <sup>b</sup>	(r + $\lambda$ )	(r + $\lambda$ )N	e <sup>-(r + <math>\lambda</math>)N</sup>	[1 - e <sup>-(r + <math>\lambda</math>)N</sup> ]	[1 - e <sup>-(r + <math>\lambda</math>)N</sup> ]/(r + $\lambda$ )	nuclide	Nuclide B <sub>AD</sub>	Nuclide Fraction	Unitized Dose <sup>c</sup> Factor (UDF)	n/f (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	3.08E-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
a: Table of the Isotopes, Seventh Edition, Lederer et al. 1978; b: Lambda = 0.693/151%;								<b>Mixture Total: Benefit of Averted Dose B<sub>AD</sub> ==&gt;</b>		\$3,087.72	1.00E+00		
c: From Table 6-2, unitized annual dose rate for contaminated concrete per dpm/100 centimeters squared								<b>Conc/DCGL<sub>w</sub> ==&gt;</b>		91.60	Sum Check	Sum	1.90E-05 1.00E+00

Table A-15

**Soil Remediation**

**Soil Excavation**  
where: 1403.1 m<sup>3</sup> ~10,000 m<sup>2</sup> @ 0.15 m deep (94%).  
And, 1403.1 m<sup>3</sup> is the estimated volume for site soil removal  
A = 10K, P<sub>D</sub> = 0.0004, r = 0.03, N = 1000  
PWAD4soiltl.wb3  
4/26/01

**ALARA EVALUATION**

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

Enter Occupancy Area in m<sup>2</sup> ==> 10,000

Enter total cost (C<sub>T</sub>, in dollars) of Action(s) ==> \$2,576,882

**Remediation Cost and Area**

Unit Cost/m <sup>3</sup>	Actual Volume M <sup>3</sup>
\$1,836.58	1403.1

**Surface Soil**

nuclide	half-life <sup>a</sup> (yrs)	$\lambda$ (yrs <sup>-1</sup> ) <sup>b</sup>	(r + $\lambda$ )	(r + $\lambda$ )N	e <sup>-(r + <math>\lambda</math>)N</sup>	[1 - e <sup>-(r + <math>\lambda</math>)N</sup> ]	[1 - e <sup>-(r + <math>\lambda</math>)N</sup> ]/(r + $\lambda$ )	nuclide	Nuclide PW(ADcollective)	Nuclide Fraction	Screening <sup>c</sup> Values (SC)	n/f (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
a: Table of the Isotopes, Seventh Edition, Lederer et al. 1978; b: Lambda = 0.693/151%;								<b>Mixture Total: Benefit of Averted Dose B<sub>AD</sub> ==&gt;</b>		\$3,511	1.00E+00		
c: From NUREG-1727 Table C2.3 pCi/g								<b>Conc/DCGL<sub>w</sub> ==&gt;</b>		733.91	Check Sum	Sum	8.38E-02 1.00E+00

**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<sup>2</sup>. 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<sup>2</sup> 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 <sup>3</sup> )
Concrete Scabble:	\$55.00 (disposal) + \$6.25 (shipping) per cubic foot (\$2163.04/m <sup>3</sup> )
Soil:	\$41.00 (disposal) + \$6.56 (shipping) per cubic foot (\$1,679.58/m <sup>3</sup> )

Round trip rail transportation:

Clive, Utah (Energy Solutions) 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<sup>3</sup>. For rail shipments the same conditions apply and result in a single car volume of 92 m<sup>3</sup> for concrete and 120 m<sup>3</sup> 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 ( $m^2$ ,  $m^3$  or 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 [ $(\$1.00/\text{g})(1.35\text{g}/\text{m}^2)(7704\text{ m}^2)$ (1.25 liquid contingency)]
Waste Disposal Cost:	\$ 33,328 Solids estimated at $0.002\text{ m}^3/\text{m}^2 = 15.4\text{ m}^3$ (\$ 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 $\text{m}^2$ :	\$19.32

### B.3 Washing and Wiping Remediation Actions

Area Evaluated For Unit Cost Determination:	7704.0 $\text{m}^2$
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 $\text{m}^2/\text{h}$
Hours:	3783.2 [ $(7704\text{ m}^2/2.8\text{ m}^2/\text{h}) +$ $4\text{h}/40\text{h set up}(1.25\text{ contingency})$ ]
Mobilization Costs	\$600
Labor Cost:	\$284,195



Equipment Costs:	\$21,571
Waste Generation:	25.4 m <sup>3</sup> (3.39E-03 m <sup>3</sup> /m <sup>2</sup> )
Waste Disposal Cost:	\$14,550 (\$573.87/m <sup>3</sup> )
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 <sup>2</sup> :	\$48.59

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

Area Evaluated For Unit Cost Determination:	7704 m <sup>2</sup>
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 <sup>2</sup> /h
Hours:	4146.4 (7704 m <sup>2</sup> /1.858 m <sup>2</sup> /h)
Mobilization Costs	\$7100
Labor Cost:	\$340,502
Equipment Costs:	\$303,682 (\$73.24/hr)*
Waste Generation:	48.9 m <sup>3</sup> = ( 7704 m <sup>2</sup> )(6.35E-3 m)
Waste Disposal Cost:	\$105,817 (\$2,163.04/m <sup>3</sup> )

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 <sup>2</sup> :	\$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 <sup>2</sup>
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 <sup>2</sup> /h
Hours:	4,146.4 [( 7704 m <sup>2</sup> /1.858 m <sup>2</sup> /h)
Mobilization Costs	\$7100
Labor Cost:	\$340,502
Equipment Cost:	\$243,062 (\$58.62/hr)
Waste Generation:	24.5 m <sup>3</sup> = ( 7704 m <sup>2</sup> )(3.18E-3 m)
Waste Disposal Cost:	\$52,908 (\$2163.04/m <sup>3</sup> )
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 <sup>2</sup> :	\$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 <sup>3</sup> = (49,344 linear feet x1.96E- 04 m <sup>3</sup> /lf at ~ 1.0 lb. per linear foot)
Waste Disposal Cost:	\$20,850 (\$ 2163.04/m <sup>3</sup> )
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

**B.6 Grit Blasting (Surfaces) Remediation Action (Bounding Condition 1.25 Contingency)**

Area Evaluated For Unit Cost Determination:	7,704 m <sup>2</sup>
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 <sup>2</sup> /hr
Hours:	3796.8 {[ (7704/2.8 m <sup>2</sup> /h) + (7704/2.8 m <sup>2</sup> /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 <sup>3</sup> = (7704 x 3.0E-03 m + 13.7m <sup>2</sup> for grit)
Waste Disposal Cost:	\$79,626 (\$2163.04/m <sup>3</sup> )
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 <sup>2</sup>	\$113.18

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

Area Evaluated For Unit Cost Determination:	7,704 m <sup>2</sup>
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 <sup>2</sup> /hr
Hours:	2761.3 (7704/2.79 m <sup>2</sup> )
Mobilization Costs	\$6,500
Labor Cost:	\$337,209
Equipment Costs:	\$143,256
Grit/Consumables	\$69,032
Waste Generation:	36.8 m <sup>3</sup> = (7704 x 3.0E-03 m + 13.7m <sup>2</sup> for grit)
Waste Disposal Cost:	\$79,626 (\$ 2163.04/m <sup>3</sup> )
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<sup>2</sup>: \$87.80

**B.7 Soil Excavation Remediation Action**

Area Evaluated For Unit Cost Determination: 1403.1 m<sup>3</sup> ( 49,550 ft<sup>3</sup>)

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<sup>3</sup>/h

Hours: 917.1 [(1403.1 m<sup>3</sup>/3.06m<sup>3</sup>/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<sup>3</sup> ( 49,550 ft<sup>3</sup>/35.315 ft<sup>3</sup>/m<sup>3</sup>)

Waste Disposal Cost: \$2,356,596 (\$1,679.58/m<sup>3</sup>)

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<sup>3</sup>: \$1,836.58

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

**MAINE YANKEE**  
**LTP SECTION 5**  
**FINAL STATUS SURVEY PLAN**

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### **Attachments**

Attachment 5A

Embedded and Buried Pipe  
Initial Final Survey Classification Description

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## **5.0 FINAL STATUS SURVEY PLAN**

### **5.1 Introduction**

#### **5.1.1 Purpose**

The Final Status Survey (FSS) Plan describes the final survey process used to demonstrate that the MY facility and site comply with radiological criteria for unrestricted use (NRC's annual dose limit of 25 mrem plus ALARA and the enhanced state clean-up levels of 10 mrem/year or less for all pathways and 4 mrem/year or less for groundwater drinking sources).

As of September 30, 2005, the only decommissioning activities that remain are those associated with the ISFSI. The information included in this section of the LTP includes historical information regarding the decommissioning of the Maine Yankee Nuclear Plant that will be maintained in its current form. This information will be reviewed, and revised as necessary, at the time of initiating the decommissioning activities for the ISFSI and associated land areas to ensure that appropriate information is available for the implementation of final status survey activities for the ISFSI and termination of the Part 50 License for the Maine Yankee site.

#### **5.1.2 Overview**

The final status survey includes remaining structures, land, and plant systems that are identified as contaminated or potentially contaminated as a result of licensed activities. A final status survey of the Independent Spent Fuel Storage Installation (ISFSI) location (land area) was initiated prior to construction of the concrete base.

There are 5 major steps in the final survey process: survey preparation, survey design, data collection, data assessment, and documentation of survey results.

##### **a. Survey Preparation**

Survey preparation is the first step in the final survey process and occurs after remediation, if necessary, is completed. In areas where remediation was required, a turnover survey may be performed to confirm that remediation was successful prior to initiating final survey activities. A turnover survey may be performed using the same process and controls as a final survey so that data from a turnover survey may be used as part of

the final survey data. In order for turnover survey data to be used for final status survey, it must have been designed and collected in compliance with LTP Sections 5.4 through 5.7 and the area controlled in accordance with Section 5.11. Following the turnover surveys, the final status survey is performed.

The area to be surveyed is isolated and/or controlled to ensure that radioactive material is not reintroduced into the area from ongoing demolition or remediation activities nearby and to maintain the final configuration of the area. Tools, equipment, and materials not needed to support survey activities are removed, unless authorized by the FSS Superintendent. Routine access, material storage, and worker transit through the area are not allowed, unless authorized by the FSS Superintendent. However, survey areas may, with proper approval, be used for staging of materials and equipment providing; 1) the staging does not interfere with performance of surveys, and 2) the external surfaces of the material or equipment are free of loose surface contamination and there is no likelihood that internal or fixed radioactive materials could escape and contaminate the surrounding area or create background concerns, and 3) the safety of survey personnel is not jeopardized.

An inspection of the area is conducted by FSS personnel to ensure that work is complete and the area is ready for final status survey. Control of activities is transferred from the Maine Yankee engineering/construction group to the FSS/RP organizations. Approved procedures provide isolation and control measures until the area is released for unrestricted use.

b. Survey Design

The survey design process establishes the methods and performance criteria used to conduct the survey. Survey design assumptions are documented in "Survey Packages" in accordance with approved procedures. The site land, structures, and systems (embedded and buried piping/conduit are the principal potentially contaminated systems that will remain after decommissioning) are organized into survey areas and classified by contamination potential as Class 1, Class 2, Class 3, or non-impacted in accordance with LTP Section 5.2 and Tables 5-1A, 5-1B, 5-1C, 5-1D, and 5-1E.

Survey unit size is based on the assumptions in the dose assessment models in accordance with the guidance provided in NUREG-1727. The

percent coverage for scan surveys is determined in accordance with LTP Section 5.4.1 and Table 5-3. The number and location of structure surface measurements (and structure volumetric samples) and soil samples are established in accordance with LTP Sections 5.4.2 through 5.4.4. Investigation levels are also established in accordance with Section 5.6 and Table 5-7.

Replicate measurements are performed as part of the quality process established to identify, assess, and control errors and uncertainty associated with sampling, survey, or analytical activities. This quality control process, described in LTP Section 5.10, provides assurance that the survey data meets the accuracy and reliability requirements necessary to support the decision to release or not release a survey unit.

c. Survey Data Collection

After preparation of a survey package, the final survey data are collected. Trained and qualified personnel perform the necessary measurements using calibrated instruments in accordance with approved procedures and instructions contained in the survey package.

d. Survey Data Assessment

Survey data assessment is performed to verify that the data are sufficient to demonstrate that the survey unit meets the unrestricted use criterion (i.e., the Null Hypothesis may be rejected.). Statistical analyses are performed on the data and the data are compared to investigation levels. Depending on the results of an investigation, the survey unit may require further remediation, reclassification, and/or resurvey. Graphical representations of the data, such as posting plots or histograms, may be generated to provide qualitative information from the survey and to verify the assumptions in the statistical tests, such as spatial independence, symmetry, data variance and statistical power. The assumptions and requirements in the survey package are reviewed. Additional data needs, if required, are identified during this review.

e. Survey Results

Survey results are documented by Survey Area in "Survey Packages." Each final survey package may contain the data from the several Survey Units that are contained in a given Survey Area. The data is reviewed,

analyzed, and processed and the results documented in a "Release Record." The Release Record provides the information necessary to support the decision to release the survey units for unrestricted use. A Final Survey Report is prepared that provides the necessary data and analyses from the Survey Packages and Release Records, and is submitted to the NRC.

### 5.1.3 Implementation

In its submittal to the NRC (MN99-26, dated 8/9/99), MY described the schedule for the phased release of site land. Two large site areas have been determined to be non-impacted (as described in Section 2 of the LTP). Details of the partial release application package are discussed in Section 1.4.2.c. The NRC granted the license amendment allowing the removal of the subject site land from the operating license by letter dated July 30, 2002. The impacted site areas are subject to a final status survey in accordance with this plan.

The final survey will be implemented in phases. The first phase was comprised of the survey of the ISFSI land and a portion of the ISFSI security operations building prior to construction of the ISFSI. The second phase includes: (a) the non-Radiological Restricted Area (RA) lands and any non-RA buildings which will remain standing within the Industrial Area; and (b) the survey of the RA land including the structural concrete which will remain three feet below grade. The third and final phase includes the ISFSI site following fuel and GTCC waste removal, facility dismantlement and any required remediation. Survey results will be described in written reports to the NRC. The actual structures and land included in each written report may vary depending on the status of ongoing decommissioning activities.

On March 15, 2004, Maine Yankee submitted letter MN-04-020 requesting an amendment to the facility operating license pursuant to 10 CFR 50.90 and in accordance with the NRC Approved License Termination Plan (LTP) for Maine Yankee, to indicate NRC's approval of the release of the Non-ISFSI site land from the jurisdiction of the license. From March 2004 to July 2005, Maine Yankee submitted supporting final status survey reports, supplements to the amendment and responses to NRC requests for additional information. On September 30, 2005, NRC issued Amendment No. 172 consisting of the unrestricted release of the remaining land under License No. DPR-36 with the exception of the land where the Independent Spent Fuel Storage Installation (ISFSI) is located and a parcel of land adjacent to the ISFSI.

Maine Yankee anticipates that both the NRC and the State of Maine Department of Human Services (DHS) - Division of Health Engineering (DHE) may choose to conduct confirmatory measurements in accordance with applicable laws and regulations. The NRC may take confirmatory measurements to make a determination in accordance with 10 CFR 50.82(a)(11) that the final radiation survey and associated documentation demonstrate that the facility and site are suitable for release in accordance with the criteria for decommissioning established in 10 CFR Part 20, subpart E. Maine state law requires Maine Yankee to permit monitoring by the Maine State Nuclear Safety Inspectors (22 MRSA 664, sub-§2, as amended by PL 1999, c. 739, §1 and 38 MRSA 1451, sub-§11, as amended by PL 1999, c. 741, §1). This monitoring includes, among other things, taking radiological measurements to verify compliance with applicable state laws (including the enhanced state radiological criteria). Maine Yankee will demonstrate compliance with the 25 mrem/yr criteria of 10 CFR Part 20, Subpart E by demonstrating compliance with the enhanced state radiological criteria. Therefore, the confirmatory measurements taken by the NRC and the State of Maine will be based upon the same criteria, that is, the Derived Concentration Guideline Level (DCGL). Timely and frequent communications with these agencies will ensure that they are afforded sufficient opportunity to perform these confirmatory measurements prior to Maine Yankee implementing any irreversible decommissioning actions (e.g., backfilling basements with fill material.)

#### 5.1.4 Regulatory Requirements and Industry Guidance

This plan has been developed using the guidance contained in the following documents:

- a. Appendix E, NUREG 1727, "Demonstrating Compliance With the Radiological Criteria for License Termination" (September 2000).
- b. NUREG-1575, "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)", Revision 1 (June 2001).
- c. NUREG-1505, "A Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys," Revision 1 (June 1998 draft).
- d. NUREG-1507, "Minimum Detectable Concentrations With Typical Radiation Survey Instruments for Various Contaminants and Field Conditions" (June 1998).



- e. Regulatory Guide 1.179, "Standard Format and Content of License Termination Plans for Nuclear Power Reactors" (January 1999).
- f. NUREG-1700, "Standard Review Plan for Evaluating Nuclear Power Reactor License Termination Plans" (April 2000).
- g. NUREG-1727, "NMSS Decommissioning Standard Review Plan" (September 2000)

Other documents used in the preparation of this plan are listed in the References Section.

## 5.2 Classification of Areas

Prior to beginning the final status survey, a thorough characterization of the radiological status and history of the site was completed. The methods and results from site characterization are described in Section 2 of the License Termination Plan. Based on the characterization results, the structures and open land areas were classified following the guidance in Appendix E of NUREG-1727 and Section 4.4 of NUREG 1575. There will be no above grade systems remaining following decommissioning. Contaminated systems will be disposed of as radioactive waste and non-radioactive systems will be disposed of as scrap. Area classification ensures that the number of measurements, and the scan coverage, are commensurate with the potential for residual contamination to exceed the unrestricted use criteria.

Initial classification of site areas is based on historical information and site characterization data. Data from operational surveys performed in support of decommissioning, routine surveillance or any other applicable survey data may be used to change the initial classification of an area up to the time of commencement of the final status survey as long as the classification reflects the levels of residual radioactivity that existed prior to remediation. Once the FSS of a given survey unit begins, the basis for any reclassification will be documented, requiring a redesign of the survey unit package and the initiation of a new survey using the redesigned survey unit package. If during the conduct of a FSS survey sufficient evidence is accumulated to warrant an investigation and reclassification of the survey unit, the survey may be terminated without completing the survey unit package.

### 5.2.1 Non-Impacted Areas

Non-Impacted areas have no reasonable potential for residual contamination because there was no known impact from site operations. These areas are not required to be surveyed beyond what has already been completed as a part of site characterization to confirm the area's non-impacted classification. The NRC issued a license amendment allowing the removal of the non-impacted site land from the operating license by letter dated July 30, 2002.

### 5.2.2 Impacted Areas

Impacted areas may contain residual radioactivity from licensed activities. Based on the levels of residual radioactivity present, impacted areas are further divided into Class 1, Class 2 or Class 3 designations. The definitions provided below are from NUREG-1727, Pages E1 and E2.

- a. Class 1 areas are impacted areas that, prior to remediation, are expected to contain residual contamination in excess of the  $DCGL_w$ .<sup>1</sup>
- b. Class 2 areas are impacted areas that, prior to remediation, are not likely to contain residual radioactivity in excess of the  $DCGL_w$ .
- c. Class 3 areas are impacted areas that have a low probability of containing residual radioactivity.

As of September 30, 2005, the only decommissioning activities that remain are those associated with the ISFSI. The information included in this section of the LTP includes historical information regarding the decommissioning of the Maine Yankee Nuclear Plant that will be maintained in its current form. This information will be reviewed, and revised as necessary, at the time of initiating the decommissioning activities for the ISFSI and associated land areas to ensure that appropriate information is available for the implementation of final status survey activities for the ISFSI and termination of the Part 50 License for the Maine Yankee site.

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<sup>1</sup> The "w" in  $DCGL_w$  refers to the Wilcoxon Rank Sum test per MARSSIM (NUREG-1575, page 2-3) but generally represents the uniform level of residual contamination that results in the dose limit, regardless of the statistical test used. See also, LTP Section 5.4.2.

### 5.2.3 Initial Classification of Basements, Land, Embedded Piping, and Buried Piping

Based on more than 19,000 measurements made during the site characterization and the information evaluated as part of the Historical Site Assessment, all land areas, basements, structures, and piping to remain after decommissioning were assigned an initial classification. The scope of the final status survey includes land and structures south of the Old Ferry Road. The areas to the north and west have been shown to meet the non-impacted criteria (LTP Section 2, Appendix A). The scope and boundaries of the FSS will be increased if survey data show significant levels of radioactivity above background in peripheral areas. (Initial Class 1 areas south of Ferry Road are shown on Figure 5-2. Additional Class 1 areas may be added as a result of ongoing characterization, remediation or survey activities.)

The primary interfaces between the impacted and non-impacted areas are the public road (Old Ferry Rd.) and the railroad spur. Both sides of the public road will be surveyed for FSS. If residual radioactivity greater than 0.5 DCGL is detected on the road or sides of the road, an investigation will be conducted to determine the extent of contamination and to identify any possible migration into the non-impacted areas. The portion of the railroad spur within the impacted area will be included in the final survey. If residual radioactivity greater than 0.5 DCGL is detected on the last 100 meters prior to exit from the impacted area, an investigation similar to that described above will be conducted.

Characterization was performed and reported by survey area. The area designations used for characterization were used, for the most part, to delineate and classify areas for final survey. This allowed the characterization data to be efficiently used for final survey area classification and for estimating the sigma value for sample size determination.

Tables 5-1A through 5-1E list the survey areas for basements, structure foundation footprints, land areas possibly augmented by structure footprints, embedded piping, and buried piping. See Attachment 5A for additional detail on embedded and buried piping and related discussions on the basis for the initial MARSSIM classification of the survey units. The major land areas are designated in Figure 5-3. For operational efficiency, each of the final survey areas listed in the tables may be subdivided into multiple areas. Smaller survey areas may be necessary to enhance the efficiency of data collection, processing, and review and serve to better support the decommissioning schedule. The classification of all subdivided survey areas will be the same as indicated in Tables 5-1A through

5-1E, unless reclassified in accordance with this LTP. The sigma values are based on site characterization data. See LTP Section 5.4.2 for the use of these sigma values in sample size determination.

Some survey areas have been assigned more than one classification based on the levels of activity found. During the FSS design process, when these areas are divided into survey units, administrative controls will ensure that each survey unit will have only one classification.

The majority of these classifications are historical, because the only areas that remain within the control of the 10 CFR 50 License are those associated with the land where the ISFSI is located and a parcel of land adjacent to the ISFSI.

Survey areas for structures that are demolished will either be applied to the remaining footprint (if the foundation is removed) or the building basement. The soil below removed foundations in the RA and Industrial areas will undergo final survey prior to backfill. The need to survey soil in excavated footprints before backfill will be evaluated on a case by case basis and documented in the Final Survey Package. The soil in the excavated footprints of several structures may be combined into a single survey area and/or survey unit if final survey is required prior to backfill. Each survey unit will be comprised of one or more structural foundation footprints, will meet the size constraints for the associated structure or structures (per Table 5-2) and will possess generally uniform characteristics, including:

- Survey unit classification
- Material type and nuclide fraction
- Sigma
- Historical radiological impact of the area

The excavated foundation areas for any building or structure outside of the IA may not be surveyed prior to backfill.

A conservative approach of classifying the excavated foundation footprints will be to classify the footprints as one class lower than would have been assigned to the foundation concrete surface. For example, if contamination below the DCGL were identified on a given foundation surface that would have resulted in the concrete surface being Class 2, the soil remaining after the foundation is removed would be given a Class 3 designation. The intent of classifying the building footprints as one classification lower (than that for the foundation concrete surface) is based on the assumption that there was no evidence of external

contamination and that the only potential for soil contamination would be building demolition. If there were any evidence of soil contamination or sub-slab contamination, such information would form the basis for the footprint classification. Absent such information, the footprint would be classified at one classification below the footprint structure. Following the satisfactory performance of FSS on the excavated foundation footprint surface, if required, the excavation area would be backfilled.

The major land areas are designated in Figure 5-3.

<b>Table 5-1A</b> <b>Survey Area Classification - Building Basements</b>								
Package Number	Survey Area-Structures	Interior		Exterior		Mean Direct Beta dpm/100cm <sup>2</sup>	Maximum Direct Beta dpm/100cm <sup>2</sup>	Approx. Survey Area Size (Meters <sup>2</sup> )
		Sigma <sup>g</sup> (dpm/100 cm <sup>2</sup> )	Class	Sigma (dpm/100 cm <sup>2</sup> )	Class			
A0100	Containment-El.-2ft	6,853	1	N/A	N/A	81,976	1,970,974	4800
A0400	Fuel Bldg.	3,606	1	N/A	N/A	6,815	312,939	300
A0600	PAB-El.11ft	3,811	2,1	N/A	N/A	1,106	32,328	2200
A1700	Containment Spray Bldg.	6,132	2,1	N/A	N/A	83,249	4,968,088	1700

**Table 5-1B**  
**Survey Area Classification-Structural Foundation Footprints**

Package Number	Survey Area-Structures	Interior		Exterior		Mean Direct Beta dpm/100cm <sup>2</sup>	Maximum Direct Beta dpm/100cm <sup>2</sup>	Approx. Survey Area Size (Meters <sup>2</sup> )
		Sigma <sup>g</sup> (dpm/100 cm <sup>2</sup> )	Class	Sigma (dpm/100 cm <sup>2</sup> )	Class			
A0500 <sup>a</sup>	DWST (Tk-21)	760	2	N/A	N/A	438	2,659	114
A0900 <sup>a</sup>	Service Bld. Hot Side	1,456	2,1	N/A	N/A	699	18,955	885
A1100	LLWSB	3,149	3,1	86	3	852	74,216	980
A1200 <sup>a</sup>	RCA Bldg.	4,880	2,1	N/A	N/A	73,939	2,233,580	290
A1300 <sup>a</sup>	Equipment Hatch	240	2,1	N/A	N/A	28	721	91
A1400 <sup>a</sup>	Personnel Hatch	1,390	2,1	N/A	N/A	350	6,758	47
A1500 <sup>a</sup>	Mechanical Penetration	812	3,2	N/A	N/A	215	3,678	134
A1600 <sup>a</sup>	Electrical Penetration	319	3	N/A	N/A	-138	557	53
A1800 <sup>a</sup>	Aux Feed Pump Rm	247	3,2	N/A	N/A	148	1,278	279
A1900 <sup>a</sup>	HV-9 Area	510	2,1	N/A	N/A	131	2,563	186
A2100 <sup>a</sup>	RWST (Tk-4)	5,293	1	N/A	N/A	3,602	54,719	148
A2200 <sup>a</sup>	BWST	3,865	1	N/A	N/A	7,270	43,189	190
A2300 <sup>a</sup>	PWST	1,262	1	N/A	N/A	668	3,258	83

<p><b>Table 5-1B</b> <b>Survey Area Classification-Structural Foundation Footprints</b></p>								
Package Number	Survey Area-Structures	Interior		Exterior		Mean Direct Beta dpm/100cm <sup>2</sup>	Maximum Direct Beta dpm/100cm <sup>2</sup>	Approx. Survey Area Size (Meters <sup>2</sup> )
		Sigma <sup>g</sup> (dpm/100 cm <sup>2</sup> )	Class	Sigma (dpm/100 cm <sup>2</sup> )	Class			
A2400 <sup>a</sup>	Test Tanks	778	1	N/A	N/A	956	4,300	180
A2600 <sup>a</sup>	LSA Bld Slab	TBD <sup>f</sup>	2,1	N/A	N/A			291
B0200 <sup>a</sup>	Control Rm	317	3	N/A	N/A	216	1054	334
B0400 <sup>a</sup>	Fire Pump House	317	3 <sup>i</sup>	N/A	N/A	10	840	104
B0500 <sup>a</sup>	Turbine Building	727	2	N/A	N/A	62	8614	3723
B0700 <sup>a</sup>	Service Bld.Cold Side	299	3,2 <sup>d</sup>	N/A	N/A	80	1622	3293
B0800 <sup>a</sup>	Fuel Oil Storage Bld.	298	3	N/A	N/A	-83	451	200
B0900 <sup>a</sup>	Diesel Generators Rooms	223	3	N/A	N/A	-177	412	Included in Turbine Bldg
B1000 <sup>a</sup>	Aux. Boiler Rm.	354	2	N/A	N/A	183	1310	Included in Turbine Bldg
B1100 <sup>a</sup>	Circ Water Pump House	319	3	N/A	N/A	-334	673	407
B1200 <sup>a</sup>	Administration Bld.	432	3	N/A	N/A	293	1628	784
B1300 <sup>a</sup>	WART Bld.	542	3	N/A	N/A	-146	1164	242



<b>Table 5-1B</b> <b>Survey Area Classification-Structural Foundation Footprints</b>								
Package Number	Survey Area-Structures	Interior		Exterior		Mean Direct Beta dpm/100cm <sup>2</sup>	Maximum Direct Beta dpm/100cm <sup>2</sup>	Approx. Survey Area Size (Meters <sup>2</sup> )
		Sigma <sup>s</sup> (dpm/100 cm <sup>2</sup> )	Class	Sigma (dpm/100 cm <sup>2</sup> )	Class			
B1400 <sup>a</sup>	Information Center	313	3	N/A	N/A	295	1929	372
B1500 <sup>a</sup>	Warehouse 2	208	3	N/A	N/A	96	539	1900
B1600 <sup>a</sup>	Training Annex	144	3	N/A	N/A	-13	708	375
B1700 <sup>a</sup>	Staff Bld.	374	3	TBD <sup>b</sup>	3	129	952.9	1431
B1900 <sup>a</sup>	Bailey House	327	3	TBD <sup>b</sup>	3	612	6,524	195
B2000 <sup>a</sup>	Bailey Barn Slab	245	3	N/A	N/A	-97	307	332
B2400	Staff Bld.-Turbine Tunnel	381	3	N/A	N/A	19	576	116
B2500	Relay House	257	3	N/A	N/A			56
D3400	LLWSB (vent and drain)	1300	3	N/A	N/A	457	3099	N/A

<p><b>Table 5-1C</b> <b>Survey Area Classification-Land</b></p>						
<b>Package Number</b>	<b>Survey Area- Land</b>	<b>Sigma <sup>s</sup> (pCi/g) Cs-137</b>	<b>Classification</b>	<b>Mean Cs-137 pCi/g</b>	<b>Max. Cs-137 pCi/g</b>	<b>Approx. Survey Area Size (Meters<sup>2</sup>)</b>
R0100	RCA yard West (Expanded to include portions of R0200, R0900 & R1000)	1.33	2,1 <sup>d</sup>	15.95	156.0	17,902
R0200	Yard East (Minus portion incorporated into R0100)	0.17	3	0.17	0.64	28,748
R0300	Roof and Yard Drains	N/A	3	0.33	0.53	Incorporated into R0100
R0400	Forebay (Expanded to include portion of R1000)	TBD <sup>e</sup>	2,1 3 dike surface soil	TBD <sup>e</sup>	TBD <sup>e</sup>	12,191
R0500	Bailey Point	0.28	3,2,1	0.36	1.09	16,046
R0600	Ball Field (Incorporated into R1800)	See R1800	See R1800	See R1800	See R1800	Incorporated into R1800
R0700	Construction Debris Landfill (Incorporated into R1800)	See R1800	See R1800	See R1800	See R1800	Incorporated into R1800
R0800	Admin and Parking Area (Minus portion incorporated into R1800)	0.13	3	0.18	0.37	31,057

<p><b>Table 5-1C</b> <b>Survey Area Classification-Land</b></p>						
<b>Package Number</b>	<b>Survey Area- Land</b>	<b>Sigma <sup>g</sup> (pCi/g) Cs-137</b>	<b>Classification</b>	<b>Mean Cs-137 pCi/g</b>	<b>Max. Cs-137 pCi/g</b>	<b>Approx. Survey Area Size (Meters<sup>2</sup>)</b>
R0900	Balance of Plant Areas (Minus portion incorporated into R0100 and R1800)	0.48	3	0.49	1.5	35,975
R1000	Foxbird Island (Minus portion incorporated into R0100 and R0400)	0.23	3	0.26	0.86	56,822
R1100	Roof and Yard Drains	NA	3	0.07	0.09	Incorporated into FR 0200
R1200	LLWSB Yard (Incorporated in R1300)	See R1300	See R1300	See R1300	See R1300	Incorporated into R1300
R1300	ISFSI (Expanded to include R1200 and portion of R2100)	0.07	3,2,1	0.09	0.28	29,240
R1500	Ash Road Area	NA	NI <sup>c</sup>	0.08	0.21	NA
R1600	Area West of Bailey Cove	NA	NI <sup>c</sup>	0.46	1.43	NA
R1700	Area North of Ferry Road	NA	NI <sup>c</sup>	0.47	1.55	NA
R1800	Bailey House Land Area	0.23	3	0.25	0.83	367,000
R2000	Diffuser	TBD <sup>c</sup>	3	0.10	0.13	TBD

<p><b>Table 5-1C</b> <b>Survey Area Classification-Land</b></p>						
<b>Package Number</b>	<b>Survey Area- Land</b>	<b>Sigma <sup>g</sup> (pCi/g) Cs-137</b>	<b>Classification</b>	<b>Mean Cs-137 pCi/g</b>	<b>Max. Cs-137 pCi/g</b>	<b>Approx. Survey Area Size (Meters<sup>2</sup>)</b>
R2100	Maintenance Yard (Incorporated into R1300 and R1800)	See R1300 & R1800	See R1300 & R1800	See R1300 & R1800	See R1300 & R1800	Incorporated into R1300 & R1800
R2300	SFPI Substation Slab Area (Incorporated into R0100)	See R0100	See R0100	See R0100	See R0100	Incorporated into R0100
R2900	Roads/Railroad Final Verification. <sup>h</sup>	See R1800	See R1800	See R1800	See R1800	1000m <sup>2</sup> roads 500m <sup>2</sup> railroads

Notes for Tables 5-1A, 5-1B and 5-1C:

- Structural footprint may be incorporated into land area as indicated in Table 5-1C.
- Exterior characterization will be conducted if buildings selected to remain standing
- "NI" refers to Non Impacted
- Contains known sub-surface or sub-slab residual activity
- To be determined upon opening the system or other pending characterization efforts
- Current background radiation levels preclude accurate survey. (Radioactive waste is still being packaged and stored in this area). Area will be surveyed when background allows.
- Sigma values listed were developed using characterization data. Sigmas may be recalculated based on post-remediation survey data.
- If contamination of 0.5 DCGL is detected in the last 100m prior to exit, an investigation as to source and impact will be conducted.

<b>Table 5-1D</b> <b>Land Areas Possibly Augmented by Backfilled Structural Footprints</b>			
<b>Land Area Package No.</b>	<b>Land Area Description</b>	<b>Structure Package No.</b>	<b>Structure Area Description</b>
R0100	RCA Yard West	A0500	DWST
		A0900	Service Bldg. Hot Side
		A1200	RCA Bldg
		A1300	Equipment Hatch
		A1400	Personnel Hatch
		A1500	Mechanical Penetration
		A1600	Electrical Penetration
		A1800	Aux Feed Pump Rm
		A1900	HV-9 Area
		A2100	RWST (Tk-4)
		A2200	BWST
		A2300	PWST
		A2400	Test Tanks
		A2600	LSA Bld

<b>Table 5-1D</b> <b>Land Areas Possibly Augmented by Backfilled Structural Footprints</b>			
<b>Land Area Package No.</b>	<b>Land Area Description</b>	<b>Structure Package No.</b>	<b>Structure Area Description</b>
R0200	Yard East	B0200	Control Rm
		B0500	Turbine Bldg
		B0700	Service Bldg. Cold Side
		B0800	Fuel Oil Storage Bldg
		B0900	Diesel Generator Rooms
		B1000	Aux. Boiler Rm
		B1100	Circ Water Pump House
		B1200	Administrative Bld. (Front Office)
		B1300	WART Bldg
		B2100	Lube Oil Storage Rm.
		B2200	Cold Machine Shop
R0800	Admin and Parking Area	B1400	Information Center
		B1600	Training Annex
		B1700	Staff Bldg.
R0900	Balance of Plant Areas	B0400	Fire Pump House
		B2600	Warehouse 5
R1800	Bailey House Land Area	B1900	Bailey House

<b>Table 5-1D</b> <b>Land Areas Possibly Augmented by Backfilled Structural Footprints</b>			
<b>Land Area Package No.</b>	<b>Land Area Description</b>	<b>Structure Package No.</b>	<b>Structure Area Description</b>
		B2000	Bailey Barn
R2600	Duct Banks	N/A	Underground Duct Banks

Table 5-1E Survey Area Classification-Embedded and Buried Pipe		
Package Number	Description	Classification
C0300	Containment Spray	Class 1
C2000	Containment Foundation Drains	Class 2
D0400	Sanitary Waste <sup>(2)</sup>	Class 3
D0500	Circulating Water	Class 3
D0700	Fire Protection (Water)	Class 3
D3500	Storm Drains	Class 1/3
D3600	Roof Drains <sup>(1)</sup>	Class 1/3
D3700	Containment Building Penetrations	Class 1
D0600	Service Water	Class 1/3

Note 1: Roof Drains will be surveyed as part of D3500 Storm Drains

Note 2: D0400 may require additional characterization surveys (see 5.2.4).



#### 5.2.4 Discussion of Initial Classification

The classification tables do not show any previously (Rev. 0) classified above grade structural elevations such as A0200 "Containment El. 20 ft.," A0300 "Containment El. 46 ft.," A0700 "PAB El. 21 ft.," A0800 "PAB El. 36 ft.," B0100 "Turbine Bld El. 61 ft.," B0300 "Motor Control Center," B0600 "Turbine Bld El. 39 ft.," or B2300 "Cable Vault." These area classifications have been removed since they are associated with upper level elevations of buildings which were demolished and the resulting debris disposed of offsite.

A detailed discussion of the basis for the classification of the embedded piping and buried piping listed in Table 5-1E is provided in Attachment 5-A.

#### 5.2.5 Changes in Classification

Initial classification of site areas is based on historical information and site characterization data. Data from operational surveys performed in support of decommissioning, routine surveillance and any other applicable survey data may be used to change the initial classification of an area up to the time of commencement of the final status survey as long as the classification reflects the levels of residual radioactivity that existed prior to remediation. Once the FSS of a given survey unit begins, the basis for any reclassification will be documented. If during the conduct of a FSS survey sufficient evidence is accumulated to warrant an investigation and reclassification of the survey unit in accordance with LTP Section 5.6, the survey may be terminated without completing the survey unit package.

#### 5.2.6 Selected Survey Area Boundaries Redefined

During the review of initial and continuing characterization, it was noted that there were some survey areas that contained areas of elevated activity that were adjacent to one another. The boundaries of these survey area were redrawn for FSS to consolidate the elevated areas into one survey area, where practical. Other survey areas were combined for efficiency because they had the same classification and characteristics. Table 5-1C and Figure 5-3 reflects the redefinition of these boundaries.

### 5.3 Establishing Survey Units

#### 5.3.1 Survey Unit

Each survey area listed in Tables 5-1A - 5-1E may be divided into discrete survey units. Survey units are areas that have similar characteristics and contamination levels. Survey units are assigned only one classification. The site and facility are surveyed, evaluated, and released on a survey unit basis.

##### a. Survey Unit Size

NUREG-1727, Appendix E, provides suggested sizes for survey units. However, as stated in NUREG-1727, page E3, the suggested survey unit sizes were based on a finding of reasonable sample density and consistency with commonly used dose modeling codes. The Basement Fill model described in Section 6 is, by necessity, not generally consistent with the "commonly used codes" because the basic conditions are different, i.e., filled basement versus standing buildings or soil contamination.

For standing buildings, the MARSSIM recommends a survey unit size of 100 m<sup>2</sup> floor area in a Class 1 area based on the dose model assumption that a 100 m<sup>2</sup> office would be occupied. The source term in this case is essentially the 100 m<sup>2</sup> floor surface; 180 m<sup>2</sup> if the lower walls are included. For soil, the recommended survey unit size for a Class 1 area was conservatively based on the dose model assumption of a 2,000 m<sup>2</sup> resident farm. The source term area in this case is 2,000 m<sup>2</sup>. For basement surfaces, the non-containment basement fill model assumes an area of 4182 m<sup>2</sup>. Therefore, the source term, and survey unit size, for basements should be based on an area of 4182 m<sup>2</sup>. For containment, the model assumes an area of 1130 m<sup>2</sup>, so the survey unit size would be limited to 1130 m<sup>2</sup>.

However, using a 4182 m<sup>2</sup> Class 1 survey unit size may not result in a "reasonable sample density" per MARSSIM. This is somewhat difficult to evaluate since MARSSIM provides no explanation for the statement and the statement is somewhat inconsistent with the MARSSIM premise that sample size is determined using DQO's and a statistically based method. To provide a rationale for a "reasonable sample density" finding, the recommended sample densities for standing building and soil surveys were evaluated.

Using the recommended survey unit sizes for standing buildings and soil, and assuming a sample size of 14 per survey unit (for the sign test with an  $\alpha$  and  $\beta = 0.05$  and relative shift = 3 as presented in Section 5.2), sample

densities of  $1/13 \text{ m}^2$  for standing buildings and  $1/143 \text{ m}^2$  for soil would be required. The primary reason for the difference in sample densities for standing buildings and soil is the source term assumptions in the dose model as described previously. Both sample densities are considered reasonable in MARSSIM. In accordance with the same logic, a sample density of  $1/298 \text{ m}^2$  would be called for in a  $4182 \text{ m}^2$  survey unit ( $14/4182$ ).

However Maine Yankee proposes to use a much higher sample density  $1/50 \text{ m}^2$  for the Class 1 basement surfaces. There is no sample density limitation for Class 2 or Class 3 basement surfaces. This value satisfies the MARSSIM "reasonable sample density" criteria since it is at the low end of the range of the recommended sample densities for standing building and soil and is consistent with the dose model assumptions. The number of samples in a survey unit will, in all cases, meet or exceed the minimum number required per survey unit in MARSSIM. For example, if a survey unit size is  $280 \text{ m}^2$ , the sample density will be  $1/20 \text{ m}^2$  to maintain the minimum 14 samples per survey unit. On the other hand, if a survey unit size is  $1000 \text{ m}^2$ , 20 samples will be collected as opposed to the 14 that are statistically required, to maintain the minimum  $1/50 \text{ m}^2$  density. In addition, if sample size adjustments are required because of scan survey MDA, the required higher sample number will be used, regardless of the sample density. The non-containment Basement surface survey unit size will be limited to  $2000 \text{ m}^2$ . The containment Basement surface survey unit size will be limited to  $1130 \text{ m}^2$ .

It is important to recognize that 100% scan survey of accessible areas is required in a Class 1 area. This provides a high level of confidence that no significant contamination will be missed. The fixed point measurements or samples are used in the statistical analysis, assuming a random distribution. For the statistical analysis, a sample density of  $1/50 \text{ m}^2$  that meets or exceeds the required MARSSIM minimum number is considered sufficient.

The actual survey unit areas and location designated within a survey area, particularly in the building basements, will be based on decommissioning operations and schedule as well as the physical configuration of the areas. Basement survey units will, in most cases be on the order  $1000 \text{ m}^2$  or less. Scale drawings of building or land areas, and walkdowns, will be used to calculate the surface area of the basement surfaces or soil within a survey area.

The survey unit sizes are related to the dose models described in Section 6. Therefore, the standing structure survey units are based on the building

occupant scenario pathways and the basement structure survey units are based on the basement fill scenario pathways. The typical survey unit sizes for building basements, soil, and standing buildings are listed in Table 5-2.

Table 5-2 Survey Unit Areas			
Class	Suggested Survey Unit Area		
	Standing Structures	Basement Structures	Land
1	180 m <sup>2</sup> *	2000 m <sup>2</sup> **	2000 m <sup>2</sup>
2	180 to 1000 m <sup>2</sup>	2000 m <sup>2</sup> **	2000 to 10 <sup>4</sup> m <sup>2</sup>
3	No Limit	No Limit	No Limit

\* includes floor and lower walls

\*\* 1130 m<sup>2</sup> for containment basement structure

Table 5-2 lists the survey unit size for basement structures as 2,000 m<sup>2</sup> surface area. Note that for embedded piping, this size is also justified since the dose model for residual radioactivity in embedded piping is identical to that used for basement structure contamination. Therefore, the same survey unit size of 2,000 m<sup>2</sup> is appropriate. For buried piping, the 2,000 m<sup>2</sup> survey is not appropriate. In fact, all of the buried pipe could be considered as one survey unit based on dose modeling assumptions. The dose model for buried piping assumes that the entire inventory of residual radioactivity in all buried piping expected to remain is instantaneously removed from the pipe surface and mixed into a volume of soil equal to the 141 m<sup>3</sup>, which is the volume of all the buried pipe. Under the assumption that this 141 m<sup>3</sup> of soil is excavated and uniformly spread over a 15 cm layer on the ground surface, it would cover an area of 940 m<sup>2</sup>. This is less than the 2,000 m<sup>2</sup> that would be allowed for surface soil. Therefore, all of the buried piping could be included in one survey unit. In actuality, as listed in Table 5-1, the buried piping will be surveyed as several distinct survey units based on physical and system considerations.

b. Site Reference Coordinate System (Reference Grid)

A reference coordinate system is used for impacted areas to facilitate the identification of survey units within the survey area. The reference coordinate system is basically an X-Y plot of the site area referenced to the state of Maine mercator projections as shown in Figures 5-4 and 5-5.

Once the reference point is established, grids may be overlaid parallel to lines of latitude and longitude.

#### **5.4 Survey Design**

This section describes the methods and data required to determine the number and location of measurements or samples in each survey unit, the coverage fraction for scan surveys, and requirements for measurements in background reference areas. The design activities described in this section will be documented in a survey package for each survey unit. Survey design includes the following:

- a. Scan Survey Coverage
- b. Sample Size Determination
- c. Background Reference Areas as necessary
- d. Reference Grid and Sample Location

LTP Section 5.4.5 describes the process for designing, developing and reviewing survey packages.

##### **5.4.1 Scan Survey Coverage**

The area covered by scan measurement is based on the survey unit classification as described in NUREG 1727 and as shown in Table 5-3 below. A 100% accessible area scan of Class 1 survey units will be required. The emphasis will be placed on scanning the higher risk areas of Class 2 survey units such as soils, floors and lower walls. Scanning percentage of Class 3 survey units will be performed on likely areas of contamination based on the judgement of the FSS engineer.

<b>Table 5-3 Scan Measurements</b>			
	<b>Class 1</b>	<b>Class 2 *</b>	<b>Class 3</b>
<b>Scan Coverage</b>	100%	10-100%	1 to 10%

\* For Class 2 Survey Units, the amount of scan coverage will be proportional to the potential for finding areas of elevated activity or areas close to the release criterion in accordance with MARSSIM Section 5.5.3. Accordingly, Maine

Yankee will use the results of individual measurements collected during characterization to correlate this activity potential to scan coverage levels.

#### 5.4.2 Sample Size Determination

NUREG-1727 describes the process for determining the number of survey measurements necessary to ensure a data set sufficient for statistical analysis. Sample size is based on the relative shift, the Type I and II errors, sigma, and the specific statistical test used to evaluate the data.

Alternate processes may be used if such gain NRC and industry acceptance between the time this plan is adopted and the commencement of final survey activities. However, any new technologies must still meet the applicable requirements of this plan for calibration, detection limit, areal coverage, operator qualification, etc.

##### a. Determining Which Test Will Be Used

Appropriate tests will be used for the statistical evaluation of survey data. Tests such as the Sign test and Wilcoxon Rank Sum (WRS) test will be implemented using unity rules, surrogate methodologies, or combinations of unity rules and surrogate methodologies, as described in MARSSIM and NUREG-1505 chapters 11 and 12.

If the contaminant is not in the background or constitutes a small fraction of the DCGL, the Sign test will be used. If background is a significant fraction of the DCGL, the Wilcoxon Rank Sum (WRS) test will be used.

##### b. Establish Decision Errors

The probability of making decision errors is controlled by hypothesis testing. The survey results will be used to select between one condition of the environment (the null hypothesis) and an alternate condition (the alternative hypothesis). These hypotheses, chosen for MARSSIM Scenario A, are defined as follows:

Null Hypothesis ( $H_0$ ): The survey unit does not meet the release criteria.

Alternate Hypothesis ( $H_a$ ): The survey unit does meet the release criteria.

A Type I decision error would result in the release of a survey unit containing residual radioactivity above the release criteria. It occurs when the null hypothesis is rejected when it is true. The probability of making this error is designated as " $\alpha$ ". A Type II decision error would result in the failure to release a survey unit when the residual radioactivity is below the

release criteria. This occurs when the Null Hypothesis is accepted when it is not true. The probability of making this error is designated as " $\beta$ ".

Appendix E of NUREG 1727 recommends using a Type I error probability ( $\alpha$ ) of 0.05 and states that any value for the Type II error probability ( $\beta$ ) is acceptable. Following the NUREG 1727 guidance,  $\alpha$  will be set at 0.05. A  $\beta$  of 0.05 will initially be selected based on site specific considerations. The  $\beta$  may be modified, as necessary, after weighing the resulting change in the number of required survey measurements against the risk of unnecessarily investigating and/or remediating survey units that are truly below the release criteria.

c. Relative Shift

The relative shift ( $\Delta / \sigma$ ) is calculated. Delta ( $\Delta$ ) is equal to the DCGL<sub>w</sub> minus the Lower Boundary of the Gray Region (LBGR). Calculation of sigmas has been discussed in Section 5.2.3 and values are provided in Tables 5-1A-C. The sigmas used for the relative shift calculation may be recalculated based on the most current data obtained from post-remediation or post-demolition surveys; or from background reference areas, as appropriate. The LBGR is initially set at 0.5 times the DCGL<sub>w</sub>, but may be adjusted to obtain an optimal value, of normally between 1 and 3 for the relative shift.

Lower Boundary of the Gray Region

The Lower Boundary of the Gray Region (LBGR) is the point at which the Type II ( $\beta$ ) error applies. The default value of the LBGR is set initially at 0.5 times the DCGL. If the relative shift is greater than 3, then the number of data points, N, listed for the relative shift values of 3 from Table 5-5 or Table 5-3 in NUREG -1575 will normally be used as the minimum sample size. Use of a relative shift greater than 3 requires approval by an FSS Engineer. If the minimum sample size results in a sample density less than the required minimum density (see Section 5.3.1), the sample size will be increased accordingly.

Sigma

Sigma values (estimate of the standard deviation of the measured values in a survey unit, and/or reference area) were initially calculated from characterization data. These sigma values can be used in FSS design or more current post-remediation sigma values can be used. The use of the sigma values from the characterization

data will be conservative for the sample size determination since the recalculated post-remediation sigmas are expected to be smaller. The sigma values for survey areas listed in Table 5-1 which contain survey units with two different classifications, will be evaluated to ensure that the sigma conservatively represents the contaminant distribution of each associated survey unit; otherwise a specific sigma value will be developed.

The sigma values for structure surfaces were calculated using the GTS characterization data measurements on concrete that were less than 20,000 dpm/100 cm<sup>2</sup>, which was a preliminary estimate of the DCGL<sub>w</sub>. This assumes that areas above 20,000 dpm/100 cm<sup>2</sup> will be remediated. Using a lower concentration should lower the sigma estimate. This method should be conservative since many contaminated areas that are near the DCGL<sub>w</sub> or near other remediated areas will likely also be remediated which would serve to reduce the higher values and the resulting sigma. The characterization measurements above 20,000 dpm/100 cm<sup>2</sup> were not truncated to 20,000 dpm/100 cm<sup>2</sup> and included since it is likely that any area remediated will be well below the DCGL<sub>w</sub>. The sigmas for soil areas were calculated using the GTS characterization data on measurements greater than MDA, and less than 8 pCi/g Cs-137. This should provide a conservative estimate of sigma for any Cs-137 DCGL<sub>w</sub> at 8 pCi/g or less.

The number of structure surface measurements taken to support the calculation of sigmas indicated in Tables 5-1A and 5-1B ranged from 7 to 98 per survey area. The number of soil measurements taken to support the calculation of sigmas indicated in Table 5-1C ranged from 5 to 73 per survey area. The structure sigmas calculated in Tables 5-1A and 5-1B represent the total gross beta activity measured down to the beta energy of C-14. If nuclides are present that have beta energies greater than that associated with C-14 they would be included in the gross measurement. The method for determining the average energy of the beta emitters is described in a supporting engineering calculation. Table 5-3a shows that the calibration sources with average beta-particle energies of  $\leq 0.107$  MeV are conservative with respect to the energy spectrum presented in the table.

The soil sigmas calculated in Table 5-1B are based upon distributed Cs-137. Sigmas may be recalculated based upon data obtained from post-remediation or post-demolition surveys.



There are some areas in containment, RCA, Fuel and Spray buildings that presently show large sigma values. After these areas are remediated, the sigma values are expected to be significantly lower. Where areas are remediated or changed, new sigma values may be calculated by taking measurements in the survey area at about 5 to 20 locations as recommended in Section 5.5.2.2. of NUREG 1575.

Table 5-3a Contaminated Media Beta Energy (KeV)			
Nuclide	Fraction 2004	Average Beta Energy (KeV)	Average Beta Energy Contribution (KeV)
H-3	2.36E-02	5.68	0.134
Fe-55	4.81E-03	0	0
Co-57	3.06E-04	0	0
Co-60	5.84E-02	95.79	5.59
Ni-63	3.55E-01	17.13	6.08
Sr-90	2.80E-03	195.80	0.55
Cs-134	4.55E-03	156.80	0.71
Cs-137	5.50E-01	170.80	93.94
Total			107.01

d. Wilcoxon Rank Sum (WRS) Test Sample Size

The number of data points, N, to be obtained from each reference area or survey unit are determined using Table 5-3 in NUREG-1575. The table includes the recommended 20% adjustment to ensure an adequate sample size.

e. Sign Test Sample Size

The number of data points is determined from Table 5-5 in NUREG-1575 for application of the Sign Test. This table includes the recommended 20% adjustment to ensure an adequate sample size.

f. Elevated Measurement Comparison (EMC) Sample Size Adjustment

If the scan MDC is greater than the  $DCGL_w$ , the sample size will be calculated using the equation provided below. If  $N_{EMC}$  exceeds the statistically determined sample size (N),  $N_{EMC}$  will replace N.

$$N_{EMC} = A/A_{EMC}$$

Where:  $N_{EMC}$  is the elevated measurement comparison sample size

A is the survey unit area

$A_{EMC}$  is the area corresponding to the area factor calculated using the  $MDC_{scan}$  concentration.

#### 5.4.3 Background Reference Areas

Background reference area measurements are required when the WRS test is used, and background subtraction may be used with the Sign test, under certain conditions such as those described in Chapter 12 of NUREG 1505. The reference area measurements will be collected using the methods and procedures required for Class 3 final survey units. For soil, reference areas will have a soil type as similar to the soil type in the survey unit as possible. When there is a reasonable choice of possible soil reference areas with similar soil types, consideration will be given to selecting reference areas that are most similar in terms of other physical, chemical, geological, and biological characteristics. For structure survey units that contain a variety of materials with markedly different backgrounds, a reference area will be selected that has similar materials. If one material is predominant or if there is not too great a variation in background among materials, a background from a reference area containing only a single material is appropriate when it is demonstrated that the selected reference area will not result in underestimating the residual radioactivity in the survey unit.

It is understood that background reference areas should have physical characteristics (including soil type and rock formation) similar to the site and shall not be contaminated by site activities. In general, Maine Yankee commits to using background reference areas, when possible, that are offsite. If non-contaminated onsite areas are to be used, then Maine Yankee will verify and justify its use by appropriate comparison with samples from appropriate off-site locations. A White Paper (technical basis document) was developed for dealing with background (Reference 5.12.35). Information from the White Paper has been included in the appropriate FSS procedure (Reference 5.12.27).

Should significant variations in background reference areas be encountered, appropriate evaluations will be performed to define the background concentration. As noted in NUREG 1727, Appendix E, Section 3.4, the Kruskal-Wallis test can be conducted in such circumstances to determine that there are no significant differences in the mean background concentrations among potential reference

areas. Maine Yankee will consider this and other statistical guidance in the evaluation of apparent significant variations in background reference areas.

If material background subtraction is performed, the sigma value used will take into account the variability of material background.

#### 5.4.4 Sample Grid and Sample Location

Sample location is a function of the number of measurements required, the survey unit classification, and the contaminant variability.

##### a. Sample Grid

The reference grid is primarily used for reference purposes and is illustrated on sample maps. Physical marking of the reference grid lines in the survey unit will only be performed when necessary. For the sample grid in Class 1 and 2 survey units, a randomly selected sample start point will be identified and sample locations will be laid out in a square grid pattern<sup>2</sup> at distance, L, from the start point in both the horizontal and vertical directions. The sample and reference grids are illustrated on sample maps and may be physically marked in the field. For Class 3 survey units, all sample locations are randomly selected, based on the reference grid. An example is shown in Figures 5-4 and 5-5. Global Positioning System (GPS) instruments may be used in open land areas to determine reference or sample grid locations within the survey area. The manufacturer's specifications indicate a horizontal accuracy of 21 feet to 45 feet for the GPS system. Digital cameras may be employed to provide a lasting record of survey location within the survey unit. When used, these photographic records will be linked to landmark and directional information to ensure reproducibility.

Note that GPS is only one method that could be used to locate land survey points. Maine Yankee is currently using a site reference grid based on the Maine mercator system and distances and angles from fixed reference points to locate survey points. If GPS is to be the sole method used to locate survey points, a more accurate system will be obtained.

##### b. Measurement Locations

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<sup>2</sup> Note that both NUREG 1575 and 1505 recognize both the rectangular and the triangular grid pattern grid method as acceptable.

Measurement locations within the survey unit are clearly identified and documented for purposes of reproducibility. Actual measurement locations are identified by tags, labels, flags, stakes, paint marks, geopositioning units or photographic record. An identification code matches a survey location to a particular survey unit.

Sample points for Class 1 and Class 2 survey units are positioned in a systematic pattern or grid throughout the survey unit by first randomly selecting a start point coordinate. A random number generator is used to determine the start point of the square grid pattern. The grid spacing, L, is a function of the area of the survey unit as shown below:

$$L = \sqrt{\frac{A}{n}} \quad \text{for a square grid}$$

where:

A = the area of the survey unit,

n = the number of sample points in the survey unit.

Sample points are located, L, distance from the random start point in both the X and Y directions.

Random measurement patterns are used for Class 3 survey units. Sample location coordinates are randomly picked using a random number generator.

Measurement locations selected using either a random selection process or a randomly-started systematic pattern that do not fall within the survey unit or that cannot be surveyed due to site conditions are replaced with other measurement locations as determined by the FSS Specialist or FSS Engineer.

#### 5.4.5 Survey Package Design Process

A Final Status Survey Package is produced for each survey area. The survey package is a collection of documentation detailing survey design, survey implementation and data evaluation for a Final Status Survey of a survey area.

Maine Yankee applies the 10CFR50, App. B requirements for field and laboratory counting equipment, as well as the corrective action process to address data or programmatic discrepancies. Using the existing Part 50,

App. B program precludes developing redundant measures for FSS activities. (See also Section 5.10.5.)

a. Survey Package Initiation

Each survey area and package is assigned a unique identification number. To allow continuity of area identification, the protocol used for identifying survey areas during the characterization survey is used, as appropriate. Numbers dissimilar to those used for characterization survey may be necessary if survey boundaries are modified.

b. Review of HSA, Characterization Surveys

The FSS Specialist gathers and reviews historical data applicable to the survey area. Historical information that will be used for survey design is filed in the survey package. Sources of historical data include:

1. Historical Site Assessment
2. Characterization Survey (Initial and Continuing)<sup>3</sup>
3. Classification basis
4. 50.75(g) files
5. Operational Survey Records

c. Survey Area Walkdown

The FSS Specialist performs a walkdown to gather information about the physical characteristics of the survey area. The walkdown provides the Specialist an opportunity to determine if any physical or safety related interferences are present that may affect survey design or survey implementation, and to determine any support activities necessary to implement surveys. The walkdown is documented and filed in the survey package.

Following the walkdown, representative maps of the survey area are prepared.

d. Survey Design

Survey Design is the process of determining the number, type and location of survey measurements or samples required for each survey unit within a survey area. The various aspects of survey design are documented and

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<sup>3</sup> For additional explanation of initial and continuing characterization surveys, see Section 2.1.

filed in the survey package. The survey unit design process is controlled by approved procedures.

The size and number of survey units for a survey area is determined based on area classification, modeling assumptions used to develop DCGL's and the layout of the survey area. The FSS Specialist will divide the area into discrete survey units as appropriate. Each survey unit is numbered sequentially. The FSS Specialist provides a description of each survey unit including survey unit size, classification and location. The types of material (i.e. soil, concrete, etc.) found in the survey unit and survey measurement and/or sampling methods are identified.

The FSS Engineer calculates the number of measurements or samples required for each survey unit in accordance with NUREG-1575. The FSS Engineer also calculates required investigation setpoints for survey measurements.

The FSS Specialist determines measurement/sample locations based on the classification of the survey unit and in accordance with NUREG-1575. A survey map is prepared of each survey unit. A sample and/or reference grid is superimposed on the map to provide an (x,y) coordinate system. The FSS Specialist generates random numbers, between 0 and 1, which are multiplied by the maximum x and y axis values of the sample grid. This provides coordinates for each sample location, or a random start location for systematic grid, as appropriate. The measurement/sample locations are plotted on the map. Each measurement/sample location is assigned a unique identification code which identifies the measurement/sample by Survey Area, Survey Unit, Material and sequential number.

The FSS Specialist determines the appropriate instruments and detectors, instrument operating modes and survey methods to be used to collect and analyze data.

The FSS Specialist prepares written survey instructions that incorporate the requirements set forth in the survey design. Direction is provided for selection of instruments, count times, instrument modes, survey methods, required documentation, alarm/investigation setpoints, alarm actions, background requirements and other appropriate instructions. The instructions also direct the appropriate instrument set up to ensure collected survey data is saved and downloaded to the appropriate files. In conjunction with the survey instructions, survey data forms, indicating desired measurements, are prepared to assist in survey documentation.

The FSS Engineer reviews the survey design and instructions and verifies, or has a competent person verify, all calculations. The FSS Engineer ensures that appropriate instruments, survey methods and sample locations have been properly identified. Once approved, the survey design and instructions are filed in the survey package.

The Superintendent of FSS reviews the survey package and authorizes survey implementation.

e. Survey Area Turnover

Prior to performing Final Status Surveys, the FSS Superintendent coordinates with appropriate site superintendents to ensure decommissioning activities, area remediation and housekeeping are complete. The FSS Superintendent may direct Radiation Protection to perform surveys to verify that the area meets the radiological criteria for performance of the Final Status Survey. When satisfied, the FSS Superintendent will direct the area to be posted, as appropriate, to indicate that the area is controlled for the performance of Final Status Surveys. Access controls are implemented to prevent contamination of areas during and following Final Status Surveys.

f. Survey Implementation

Survey areas and/or locations are identified by gridding, markings, or flags as appropriate. The FSS Supervisor performs a pre survey briefing with the survey technicians during which the survey instructions are reviewed. The technicians gather instruments and equipment as indicated and perform surveys in accordance with the appropriate procedures. Technicians are responsible for documenting survey results and maintaining custody of samples and instrumentation. At the completion of surveys, technicians return instruments for downloading and prepare samples for analysis.

Survey instruments provided to the technicians are prepared in accordance with appropriate procedures and the survey instructions. Instruments are performance checked prior to and following surveys. Any data collected in data logging instruments is downloaded and a hard copy printed out. The download hard copies, surveyor's data sheets and sample counting reports are reviewed and forwarded for inclusion in the survey package. The FSS Supervisor is notified of any data that exceeds investigation criteria so that appropriate investigation surveys and remediation can be performed as necessary. The downloaded data file is backed up to the system server and to appropriate storage media on a routine basis.

Several quality control measures and features have been developed for the implementation phase of the final status survey program. These elements typically include:

- Pre-implementation briefings between FSS design and implementation personnel,
- Pre-implementation area walkdowns,
- Survey location verification,
- Daily survey area background measurements,
- Instrument source checks before and after survey activities and
- Conduct of surveys in the peak trap mode, thereby providing a record of the maximum scan value for any scan grid.

g. Data Evaluation

The FSS Specialist reviews survey data, data downloads and counting reports to verify completeness, legibility and compliance with survey design. As directed by the FSS Engineer, the FSS Specialist performs the following:

1. Converts data to reporting units
2. Calculates mean, median and range of the data set
3. Reviews the data for outliers
4. Calculates the standard deviation of the data set
5. Calculates MDC for each survey type performed
6. Creates posting, frequency or quantile plots for visual interpretation of data.

The FSS Engineer reviews and verifies the statistical calculations, verifies the integrity and usefulness of the data set and determines the need for further data. The FSS Engineer will direct investigation as necessary. Once satisfied that the data are valid, the FSS Engineer will perform the appropriate statistical test and make a decision on the radiological status of each survey unit.

The data evaluation process is documented and filed in the survey package.

h. Quality Control Surveys

Following completion of Final Status Survey, the need for QC surveys (replicate surveys, sample recounts, etc.) is determined. If necessary, a QC survey package is developed and modeled after the original survey. QC measurement results are compared to the original measurement results. If QC results do not agree with the original survey, an investigation is



performed. Following investigation, the FSS Engineer will decide data validity.

i. Release Record

Following data evaluation, The FSS Engineer prepares a Release Record. The Release Record describes the survey area, survey design, survey units, surveys performed and instruments used. The Release Record summarizes survey results and data evaluation. The Release Record is reviewed and approved by the FSS Superintendent and the Manager of Projects - FSS.

5.5 Survey Methods and Instrumentation

5.5.1 Survey Measurement Methods

Survey measurements and sample collection are performed by personnel trained and qualified in accordance with the applicable procedure. The techniques for performing survey measurements or collecting samples are specified in approved procedures. Final site survey measurements include surface scans, direct surface measurements, and gamma spectroscopy of volumetric materials. In situ gamma spectroscopy or other methods not specifically described may also be used for final status surveys. If so, Maine Yankee will give the NRC 30 days notice to provide an opportunity to review the associated basis document<sup>4</sup> as described in LTP Section 5.3.1.

On-site lab facilities are used for gamma spectroscopy, liquid scintillation and gas proportional counting in accordance with applicable procedures. Off-site facilities are used, as necessary. No matter which facilities are used, analytical methods will be administratively established to detect levels of radioactivity at 10% to 50% of the DCGL value or below the ALARA Remediation Level, if applicable.

a. Structures

Structures will receive scan surveys, direct measurements and, when necessary, volumetric sampling.

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<sup>4</sup>

A Technical Basis Document was submitted for: "Forebay FSS Survey Measurement Methods (In-Situ Gamma Spectroscopy)" - References 5.12.37 and 5.12.38

### Scan Surveys

Scanning is performed in order to locate small areas of residual activity above the investigation level. Structures are scanned for beta-gamma radiation with appropriate instruments such as those listed in Table 5-4. The measurements will typically be performed at a distance of 1 cm or less from the surface and at a scan speed of 5 cm/sec for hand-held instruments. Adjustments to scan speed and distance may be made in accordance with approved procedures. Sodium iodide detectors may be used for scanning of concrete surfaces when surface conditions would result in increased surface to detector distance (typically within 3 inches) and when the static measurement sample size is adjusted for the corresponding MDC, if necessary. In situ gamma spectroscopy may be effectively substituted for scanning surveys if technically justified following the 30 day NRC notice and opportunity to review as described previously.

### Direct Measurements

Direct measurements are performed to detect surface activity levels. Direct measurements are conducted by placing the detector on or very near the surface to be counted and acquiring data over a pre-determined count time. A count time of one minute is typically used for surface measurements and generally provides detection levels well below the DCGL. (The count time may be varied provided the required detection level is achieved).

### Concrete With Activated Radionuclides

Residual radioactivity within activated building materials was conservatively estimated by performing gamma spectroscopy on core slices taken from long concrete cores located in selectively higher than average neutron fluence locations for the concrete volumes represented by the cores. This activity inventory was established as the DCGL and was evaluated for dose consequences using realistic release assumptions as described in Reference 6.10.7. Because of the low dose consequences, no other final status survey requirements were established to measure the activated concrete activity. However, measurements of total activated activity were estimated using in-situ gamma spectroscopy to provide verification within the bounds of uncertainty.

### Volumetric Concrete Measurements

Volumetric sampling of contaminated concrete, as opposed to direct measurements may be necessary if the efficiency or uncertainty of the gross beta measurements are too high. Volumetric concrete samples will be analyzed by gamma spectroscopy. The results will either be evaluated by 1) calculating the derived total gross beta cpm/100 cm<sup>2</sup> in the sample and comparing the gross beta results directly to the gross beta DCGL or 2) by using the radionuclide specific results to derive the surface activity equivalent and determine compliance using the unity rule. Use of the unity rule will require the use of a surrogate calculation to account for the radionuclides in the mixture not identified by gamma spectroscopy. This will be accomplished using the nuclide mixture listed in Tables 2-7 or 2-8 as appropriate.

Volumetric samples analyzed by gamma spectroscopy will detect the presence of radioactivity below the surface. Such sampling is typically performed following removal of paint and other surface coatings during remediation. After analysis, the data may be converted to equivalent surface activity for crack analysis.

### Removable Contamination Surveys

Based on current decommissioning planning, there will be no standing buildings remaining within the Restricted Area and only one building remaining outside the Restricted Area, namely, the switchyard relay house (per LTP Sections 3.2.4 and 6.9.1). Removable contamination surveys will be collected at discreet locations in the switchyard relay house.

#### b. Soil

Soil will receive scan surveys at the coverage level described in Table 5-3 and volumetric samples will be taken at designated locations. Surface soil samples will normally be taken at a depth of 0 to 15 cm. Areas of sub-surface soil contamination may require sampling at a depth exceeding 15 cm. The possibility of sub-surface contamination will be considered during the survey design process and the survey design package will contain requirements for sampling soil below 15 cm. Samples will be collected and prepared in accordance with approved procedures.

### Scans

Open land areas are scanned for gamma emitting nuclides. The gamma emitters are used as surrogates for the HTD radionuclides. Sodium iodide

detectors are typically used for scanning. For detectors such as the SPA-3, the detector is held within a few centimeters of the ground surface and is moved at a speed of 0.25 m/sec, traversing each square meter 5 times. The area covered by scan measurements is based on the survey unit classification as described in Section 5.4.1.

#### Volumetric Samples

Soil materials are analyzed by gamma spectroscopy. Soil samples of approximately 1500 grams are normally collected from the surface layer (top 15 cm). If contamination below 15 cm is suspected, split spoon sampling or other methods, will be used for the final survey unless the area has already been excavated and remediated to the deep soil DCGL. If an area containing subsurface contamination has been remediated, the excavated area will be treated as a surface soil.

The areas around the RWST and Fuel Building are two of the areas that will require remediation and possibly sub-surface sampling. Subsurface sampling will be performed in accordance with the guidance in NUREG-1727, page E18, Section 11.1. The sample size for subsurface samples will be determined using the same methods described for surface soil. Per NUREG-1727, scanning is not applicable. Samples will be composited over each 1 m of depth and collected to depths at which there is high confidence that deeper samples will not result in higher concentrations. The area factors derived for surface soil will be applied to subsurface soil in Class 1 areas.

Sample preparation includes removing extraneous material and homogenizing and drying the soil for analysis. Separate containers are used for each sample and each container is tracked through the analysis process using a chain-of-custody record. Samples are split when required by the applicable FSS Quality Control procedure.

#### Sub-Slab Soils

Grade level foundation slabs will be removed during demolition which will afford the opportunity to sample the soil underneath the slab. The floor slabs or foundations remaining in place after demolition (at elevations less than 3 feet below grade) may be evaluated by taking samples immediately adjacent to the slab using a split spoon or core sampler depending on the contamination potential. Factors that will be evaluated to determine the need for split spoon sampling include: (1) existence of soil under the slab; (2) acceptability of alternate means of identifying the potential for sub-slab contamination, e.g., groundwater sampling; and (3) operational history.

### Stored Excavated Soil

Several piles of soil have been stored on-site that were excavated from Class 3 areas. Prior to placing any soil into a pile for storage and possible future use, survey measurements are made. Scan surveys are conducted over approximately 10% of the area to be excavated using methods equivalent to FSS. Soil samples are also collected and analyzed to ensure that there is no indication of previously undetected soil contamination. Once these measurements are completed, the soil is excavated and placed into storage. The Maine Yankee soil control procedure is used to track the origin, storage location, and final disposition location of the soil. Prior to any stored soil being placed in any location on site, the sampling techniques described in Section 5.5.1.b are employed to further assure that the soil met the requirements of the area in which it was being used. This stored soil could be used for backfilling the soil excavation areas after additional volumetric sampling. Stored soil will not be used for RA basement fill. The following strategy will be followed.

Assuming the WRS test will be used,  $\alpha = \beta = 0.05$ , and a  $\Delta / \sigma$  value of 3, the sample size would be 10. Based on the soil sigma data in Table 5-1C, it is likely that the  $\Delta / \sigma$  value will be equal or greater than 3. For a Class 3 surface soil survey unit of 10,000 m<sup>2</sup>, the equivalent volumetric sample density would be 10 samples per 1,500 m<sup>3</sup> (10,000 m<sup>2</sup> x 0.15 m depth of soil sample) or 1/150 m<sup>3</sup>.

Using the WRS test sample size to determine a volumetric sampling frequency is consistent with the methods recommended for subsurface soil in NUREG-1727, Appendix E, Section 11.1. Regardless of the soil pile volume, a minimum of 10 samples will be collected. If the soil pile volume exceeds 1500 m<sup>3</sup>, additional samples will be collected to ensure the 1/150 m<sup>3</sup> sample frequency is maintained. Soil piles from various class 3 areas may be combined prior to sampling. The origin, storage and final use of soil is controlled by an approved soil control procedure.

Soil excavated from Class 1 and 2 areas may be reused for backfill of excavated areas of the same or higher classification (eg. Class 2 stored soil may be used to backfill Class 1 or 2 excavated areas; Class 1 stored soil may be used only to backfill Class 1 excavated areas). The survey and sampling protocols will be the same or equivalent to that described above for Class 3 stored soil with the following exceptions:

1. The pre-excavation surface scan or equivalent technique will provide 100% coverage
2. The soil pile volumetric sample density will be calculated based upon a surface survey unit size of 2000 m<sup>2</sup> and a  $\Delta / \sigma$  value of 0.9.

Thus, the equivalent volumetric sample density would be 40 samples per 300 m<sup>3</sup> (2000 m<sup>2</sup> x 0.15 m depth of soil sample) or 1 sample per 7.5 m<sup>3</sup>.

In-Situ Gamma Spectroscopy may be employed, as appropriate, in lieu of pre-excavation sampling and scanning. Soil routinely excavated for non-remediation purposes from areas which have been successfully FSS'ed may be used to backfill the excavation without additional survey.

c. Embedded Piping and Buried Piping

The only systems to remain after decommissioning are embedded piping and buried piping. The piping expected to remain was described in detail in the Section 2. A detailed description of the final survey methods is provided in Attachment 5A.

d. Specific Areas and Conditions

Cracks, Crevices, Wall-Floor Interfaces and Small Holes

Surface contamination on irregular structure surfaces (e.g., cracks, crevices, and holes) are difficult to survey directly. Where no remediation has occurred and residual activity has not been detected above background, these surface blemishes may be assumed to have the same level of residual activity as that found on adjacent surfaces. The accessible surfaces are surveyed in the same manner as other structural surfaces and no special corrections or adjustments have to be made.

In situations where remediation has taken place or where residual activity has been detected above background, a representative sample of the contamination within the crack or crevice may be obtained or an adjustment for instrument efficiency may be made if justifiable. If an instrument efficiency adjustment cannot be justified based on the depth of contamination or other geometry factors, volumetric samples will be collected. The total dpm/100 cm<sup>2</sup> contained in the volumetric sample that is attributable to the beta emitting radionuclides used to determine the DCGL will be compared directly to the concrete gross beta DCGL. As an alternative, radionuclide specific analysis, coupled with application of the unity rule may be used.

Volumetric samples analyzed by gamma spectroscopy will detect the presence of radioactivity below the surface. Such sampling is typically performed following removal of paint and other surface coatings during remediation. After analysis, the data may be converted to equivalent surface

activity for crack analysis.

The accessible surfaces are surveyed in the same manner as other structure surfaces except that they are included in areas receiving judgmental scans when scanning is performed over less than 100% of the area.

#### Paint Covered Surfaces

Final status surveys will consider the effect of painted surfaces. Gross measurements will not be used in areas covered by thick painted surfaces that are not remediated. The surfaces will be volumetrically sampled or the coating will be removed prior to survey. No special consideration must be given to wall or ceiling areas painted before plant startup and which have not been subjected to repeated exposure to materials that would have penetrated the painted surface.

#### Pavement-Covered Areas

The survey design of parking lots, roads and other paved areas will be based on soil survey unit sizes since they are outdoor areas where the exposure scenario is most similar to direct radiation to surface soil. The DCGL applied to these areas will be equal to the buried piping DCGL. Scan and static gamma and beta-gamma surveys are made as determined by the survey unit design. If sub-surface contamination is possible under paved or other covered areas, sub-surface volumetric samples will be collected. Paved areas may be separate survey units or they may be incorporated into other, larger survey open land units. Surveys of paved areas will include the area within road right-of-ways to check for radioactivity relocated due to water runoff. The right-of-ways may be separate survey units.

The buried pipe model, as described in Section 6.6.8, is based on the release of surface contamination (inside piping) into soil. The potential dose from paved areas is also from the release of surface contamination into soil. The soil concentration calculated in the buried pipe model was determined assuming a surface area to soil volume ratio that was higher than would likely occur in the case of paved surfaces. This would lead to higher soil concentrations from release of contamination from the buried piping than was calculated for the paved surfaces. In addition, the buried piping DCGL was limited to ensure that the resulting hypothetical soil concentrations would be below the surface soil DCGL's. The combination of conservative assumptions included in the buried piping dose model and the similarity of the ultimate dose pathways make it suitable for application to the paved surfaces.

### Forebay Sediment

The NRC released the Forebay area in September 2005. This area is no longer controlled in accordance with the 10 CFR 50 License.

#### 5.5.2 Instrumentation

Radiation detection and measurement instrumentation for the final status survey is selected to provide both reliable operation and adequate sensitivity to detect the radionuclides identified at the site at levels sufficiently below the DCGL. Detector selection is based on detection sensitivity, operating characteristics and expected performance in the field. The instrumentation will, to the extent practicable, use data logging with bar code scanning capability.

Commercially available portable and laboratory instruments and detectors are typically used to perform the three basic survey measurements: 1) surface scanning; 2) direct surface contamination measurements; and 3) spectroscopy of soil and other bulk materials, such as concrete. The Instrumentation Program Procedure controls the issuance, use, and calibration of instrumentation. Records supporting the Instrumentation Program are maintained by Document Control.

##### a. Selection

Radiation detection and measurement instrumentation is selected based on the type and quantity of radiation to be measured. (The instruments used for direct measurements are capable of detecting the radiation of concern to a Minimum Detectable Concentration (MDC) of between 10% and 50% of the applicable DCGL. The use of 10% to 50% of the DCGL is an administrative limit only. Any value below the DCGL is acceptable in Class 1 or 2 survey units. MDCs of less than 50% of the DCGL allow detection of residual activity in Class 3 survey units at an investigation level of 0.5 times the DCGL. Instruments used for scan measurements in Class 1 areas are required to be capable of detecting radioactive material at the DCGL<sub>EMC</sub>.)

Instrument MDCs are discussed in Section 5.5.2 (d) and nominal MDC values are listed in Table 5-6. Instrumentation currently proposed for used in the final status survey is listed in Table 5-4. Maine Yankee follows instrument manufacturers recommendations and/or supporting basis documents for considerations such as temperature dependency.

As the project proceeds, other measurement instruments or technologies, such as in-situ gamma spectroscopy or continuous data collection scan devices, may be found to be more efficient than the survey instruments proposed in this plan. The acceptability of such an instrument or technology for use in the final survey program would be justified in a technical basis



document. The technical basis document would include among other things the following: (1) a description of the conditions under which the method would be used; (2) a description of the measurement method, instrumentation and criteria; (3) justification that the technique would provide equivalent scan coverage for the given survey unit classification and that the scan MDC is adequate when compared to the  $DCGL_{EMC}$ ; and (4) a demonstration that the method provides data that has a Type 1 error (falsely concluding that the survey unit is acceptable) equivalent to 5% or less and provides sufficient confidence that  $DCGL_{EMC}$  criteria is satisfied.

b. Calibration And Maintenance

Instruments and detectors are calibrated for the radiation types and energies of interest at the site. The calibration sources for beta survey instruments are Tc-99, Cs-137, or Co-60 because the average beta energy (100 keV) approximates the beta energy of the radionuclides found on surfaces or in piping on site (85-94 keV). The alpha calibration sources when used are Am-241 or Th-230 which have an appropriate alpha energy for plant-specific alpha emitting nuclides. Gamma scintillation detectors are calibrated using Cs-137, but the energy response to Co-60 has also been determined since discrete areas of Co-60 contamination have been found by soil surface scans.

Table 5-4 Final Status Survey Instruments				
Measurement Type	Detector Type	Detector Total Area/ Density	Typical Manufacturer & Model #	Units
Surface Alpha/Beta-Gamma	Gas Flow Proportional	126 cm <sup>2</sup> 0.8 mg/ cm <sup>2</sup>	Ludlum 43-68	cpm
Surface Alpha/Beta-Gamma	Large Area Gas Flow Proportional	584 cm <sup>2</sup>  821 cm <sup>2</sup> (both 0.8 mg/cm <sup>2</sup> )	Ludlum 43-37  43-37-1	cpm
Surface Beta -Gamma	G-M	15.5 cm <sup>2</sup> 2mg/ cm <sup>2</sup>	LND, TGM Eberline SHP-360	cpm
Gamma Scan	NaI(Tl)	2"x2"	Eberline SPA-3	cpm
Liquid Beta	Scintillation	N/A	Beckman	μCi
Smear Beta-Gamma	Gas Proportional	15.5 cm <sup>2</sup> 0.8 mg/ cm <sup>2</sup>	Tennelec	dpm
Gamma Spectroscopy	HP Ge	N/A	Canberra	pCi

Instrumentation used for final status survey will be calibrated and maintained in accordance with the Instrumentation Program procedure. Radioactive sources used for calibration are traceable to the National Institute of Standards and Technology (NIST) and have been obtained in standard geometries to match the type of samples being counted. If vendor services are used, these will be obtained in accordance with purchasing requirements for quality related services, to ensure the same level of quality.

c. Response Checks

Instrumentation response checks are conducted to assure proper instrument response and operation. An acceptable response for field instrumentation is an instrument reading within +/- 10% of the established check source value. Laboratory instrumentation standards will be within +/- 3 sigma as documented on a control chart. Response checks are performed daily before instrument use and again at the end of use. Check sources contain the same type of radiation as that being measured in the field and are held in fixed-geometry jigs for reproducibility. If an instrument fails a response check, it

is labeled "Do Not Use" and is removed from service until the problem is corrected in accordance with applicable procedures. Measurements made between the last acceptable check and the failed check are evaluated to determine if they should remain in the data set.

d. Minimum Detectable Concentration (MDC)

The MDC is determined for the instruments and techniques used for final status surveys (Table 5-6). The MDC is the concentration of radioactivity that an instrument can be expected to detect 95 percent of the time.

Static MDC For Structure Surfaces

For static (direct) surface measurements, with conventional detectors, such as those listed in Table 5-4, the MDC is calculated as follows:

$$\text{MDC}_{\text{static}} = \frac{3 + 4.65\sqrt{B}}{(K)(t)}$$

where:

$\text{MDC}_{\text{static}}$  = minimum detectable concentration for direct counting (dpm/100 cm<sup>2</sup>),

B = background counts during the count interval t (counts),

t = count interval (for paired observations of sample and blank, usually 1 minute),

K = calibration constant (counts/min per dpm/100 cm<sup>2</sup>),

The value of K includes correction factors for efficiency ( $\epsilon_i$  and  $\epsilon_s$ ).

The value of  $\epsilon_s$  is dependent on the material type.

Corrections for radionuclide absorption have been made.

Open Land Area and Structure Scan MDC Using Alarm Set Point

The MDC formulae described in NUREG-1507 rely on the audible response of the meter. Maine Yankee proposes to use the E-600 instrument, a so called "smart meter," coupled to an appropriate detector for performing scan surveys for both structures and soil. This allows data logging and a more objective evaluation of scan MDC based on an alarm set point. The probability of alarm was calculated through simulation of instrument performance and compared to the  $\text{DCGL}_{\text{EMC}}$ , which was calculated using the area factors established in Sections 6.8 and 6.9. The extent of scan coverage

is commensurate with the radiological conditions and classification of the survey unit in accordance with Table 5-3.

The determination of the alarm set-points and the DQO Type I error rate of 0.05 are based on using a 2 X 2 NaI detector moving at 0.25 m/sec at a distance of 2 inches from the soil surface. The error rate was calculated, and determined to be acceptable, using an E-600 instrument with a weighting factor of 5. The FSS procedures require a weighting factor of 5 to be applied during FSS scan surveys.

Prior to beginning the scan survey on an area, the local area background for a given survey unit or portion of a survey unit is determined. The FSS survey designer walks down the area and determines the number of potentially different background areas or materials. The designer then determines the number of measurements that need to be taken within the area in order to establish the local background. The technician collects the required number of measurements as well as soil samples and in situ gamma spectroscopy readings to ensure that the background values are not influenced by plant-derived radioactive materials. The average background reading is used to calculate the alarm set-point. This process ensures the appropriate determination and application of background characteristics in survey units with multiple media.

Before entering the survey unit grid<sup>5</sup> to begin a scan, the technician takes a one minute background count to ensure the background has not changed. If the background reading meets the expectation value, the technician performs the scan survey of the grid. The technician verifies the local area background is within plus or minus 1000 cpm of the expected value. If the background exceeds +/-1000 cpm or the instrument repeatedly alarms, the technician stops the survey and requests the FSS engineer to re-evaluate background and adjust the alarm set-point as necessary. Using the conversion factor derived in Maine Yankee's technical basis document (Reference 5.12.32), 1000 cpm is equivalent to about 2.2 pCi/g. Maine Yankee will add 2.2 pCi/g to the scan MDC for open land areas to account for the possibility that the background in a scan grid could decrease by up to 1000 cpm before the alarm set-point is readjusted.

The scan MDC's for open land areas using the E-600 instrument with an alarm set point are listed in Table 5-4a. The listed MDC's were selected to ensure a Type I error rate less than 0.05. The 0.05 Type I error rate is achieved by apportioning a 0.025 error rate to the first stage scan and a 0.025 error rate to the second stage scan.

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<sup>5</sup> The scan grid size is limited to no greater than 10 square meters so that background fluctuation is not a concern (Reference 5.12.36)

The MDC calculation and results are described in a Maine Yankee technical basis document (Reference 5.12.32). Maine Yankee will multiply the MDC by a factor of 1.15 which accounts for uncertainty due to variability in scan speed and detector distance from the soil surface. The *a priori*  $DCGL_{EMC}$  used for survey planning for soil survey units will be based on the scan MDC associated with a 2 m<sup>2</sup> land area at a 0.025 Type 1 error rate, corrected by a factor of 1.15 to account for variable scan speed and distance and increased by 2.2 pCi/g, i.e., 5.9 pCi/g Cs-137. Table 5-4a lists the DCGL for areas outside the RA. The DCGL for areas inside the RA is 2.39 pCi/g Cs-137. (See Section 6.7.2 for the determination of the DCGL and application of surrogates.)

The survey is performed in the peak trap mode and the highest value obtained in the survey grid is logged.

The beta-gamma scan MDC for structures using the E-600 instrument with an alarm set point are listed in Table 5-4b. The listed MDC's were selected to ensure a Type 1 error rate less than 0.05. The MDC calculation and results are described in a Maine Yankee technical basis document (Ref. 5.12.32). Survey planning for structure survey units will be based on the scan MDC associated with a 0.5 m<sup>2</sup> surface area, i.e., 1832 dpm/100 cm<sup>2</sup> for a 600 c/m background. Table 5-4b lists the DCGL for areas of 600 and 2000 c/m background. The DCGL for structures is 18,000 dpm/100 cm<sup>2</sup>. (See Section 6.7.2 for the determination of the DCGL and the application of surrogates). The gamma scan MDC's for concrete structures using the E-600 instrument with an alarm set point are described using the Maine Yankee gamma scan technical basis document (Ref. 5.12.34).

The structure beta-gamma scan survey is performed using a gas flow proportional detector moving at 5 cm/sec at a distance of 1.0 cm from the structure surface. The survey is performed in the peak trap mode with the highest value obtained in the survey grid logged. The concrete structure gamma scan may be performed using sodium iodide detectors when surface conditions would result in increased surface to detector distance (typically within 3 inches) and when the static measurement sample size is adjusted for the corresponding MDC, if necessary.

<b>Table 5-4a</b> <b>Land Area Scan MDC for E-600 Instrument</b> <b>(Outside Restricted Area - DCGL = 4.2 pCi/g)*</b>								
	Scan Area (m <sup>2</sup> )							
	0.5	1	2	4	6	8	16	25
Area Factor	22.3	12.0	6.8	4.1	3.2	2.8	2.0	1.7
DCGL <sub>EMC</sub>	93.7	50.4	28.6	17.2	13.4	11.8	8.4	7.1
MDC <sub>5s</sub> (pCi/g) Type 1 = 0.05	4.5	3.6	3.2	3.0	2.5	2.5	2.5	2.0

\*See Section 6.7 for explanation of DCGL calculated for areas outside the Restricted Area

<b>Table 5-4b</b> <b>Structure Beta-Gamma Scan MDC for E-600 Instrument</b>						
	Scan Area (m <sup>2</sup> )					
	0.03	0.06	0.10	0.20	0.50	1.00
Area Factor	1667	847	500	250	100	50
MDC (with 600 c/m bkg) dpm/100 cm <sup>2</sup>	4884	3663	3053	2442	1832	1221
MDC (with 2000 c/m bkg) dpm/100 cm <sup>2</sup>	9157	6720	5490	4270	3660	3053

e. Detection Sensitivity

The nominal detection sensitivity of some of the detectors that may be used for surface contamination surveys has been determined and is provided in Table 5-6.

Count times are instrument-specific and are selected to ensure that the measurements are sufficiently sensitive for the DCGL. For example, the count times associated with surface activity surveys (1 minute) and gamma spectroscopy of volumetric materials (17 minutes) are administratively established to achieve MDCs less than the DCGL. The MDC<sub>scan</sub> values are also below the DCGL shown in Table 5-6. The MDC<sub>scan</sub> values may not always be less than the DCGL<sub>w</sub>, but will be less than DCGL<sub>EMC</sub>.

A technique for performing land scans with a SPA-3 detector coupled to the E-600 has been developed which is capable of detecting discrete Co-60 particles of 1 uCi activity buried at a depth of six inches in soil. This capability has been confirmed by actual field testing using this detector with

the E600, as documented in a technical basis document (Reference 5.12.32).

Cs-137 sensitivity was determined to be 3 pCi/g Cs-137 in a 2m<sup>2</sup> area. This is based on modeling the SPA-3/E600 combination, as documented in Reference 5.12.32 and confirmed by field testing.

The E600 instrument will be operated in the single channel analyzer mode when used in scan surveys to optimize the instrument's energy spectrum sensitivity.

f. Total Efficiency ( $E_t$ ) and Source Efficiency ( $E_s$ ) for Concrete Contamination

Section 6.6 provides a detailed description of the dose assessment for contaminated basement concrete. The source term input to the groundwater calculations is the total inventory within the basement concrete. This inventory appears to be primarily located within the first mm of the concrete surface. Various fixed point measurement alternatives for determining the source term were evaluated including gross beta measurements on the surfaces, volumetric concrete sampling and in-situ gamma spectroscopy. Gross beta fixed point measurements were determined to be cost-effective and technically defensible under the assumption that the instrument efficiencies for concrete could be satisfactorily calculated using the methods recommended in NUREG-1507.

For scan surveys, gross beta measurements appear to be the only practical method. Under certain conditions, in-situ gamma spectroscopy may be a reasonable method for replacing beta scan surveys. If in-situ gamma spectroscopy is used, a technical basis document will be developed demonstrating its suitability for final survey measurements and NRC will be notified 30 days prior to its first use.

The methods for determining efficiency in NUREG-1507 were specifically developed to address situations when the source, in this case concrete, affects radiation emission rate due to self-attenuation, backscatter, thin coverings, etc. This method accounts for these source effects by separating the efficiency calculation into two components, i.e., instrument efficiency  $E_i$  and source efficiency  $E_s$ . The total efficiency  $E_t$  is the product of  $E_i$  and  $E_s$  as shown below.

$$E_t = (E_i)(E_s)$$

The  $E_i$  was determined by calibration to a NIST traceable, large area Tc-99 source. The  $E_s$  value was determined empirically through measurements of concrete cores collected from representative site locations. The empirically derived value of 0.35 compares reasonably with the ISO standard default values of 0.25 for betas less than 0.4 MeV and 0.5 for betas greater than 0.4 MeV, considering most of the concrete activity is Cs-137 with a beta energy greater than 0.4. Forty three cores were obtained from concrete floors of the buildings known to be contaminated. Cores were collected from the Containment Building loop areas which were considered to represent reactor coolant contamination. Spray Building cores were representative of the ECCS (emergency core cooling system) contamination. Cores collected in the PAB were representative of the waste processing system contamination. The RCA Building cores represented waste systems and decontamination activities. Fuel Building cores represented the spent fuel pool contamination events. Several cores were taken from each building. The core nuclide activities were determined by gamma spectrometry, geometry corrected, then the pCi/g result was multiplied by the mass of the core sample and converted to total gross beta dpm.

The cores were moved to a low background area and counted for gross beta using final survey instrumentation. The cores were initially counted for 1 minute, corrected for background and reported as net cpm. The instrument total efficiency,  $E_t$ , was calculated as the ratio of the net count rate divided by the net activity in dpm. The initial efficiency data resulted in a mean efficiency of 0.148 with a standard deviation of 0.11. The data showed wide variability with approximately 50% of the individual efficiency values within one standard deviation of the mean. (Tchebycheff's theorem states that 68% of the values of a normally distributed population should be within one standard deviation of the mean.)

The core efficiency data have undergone a re-evaluation since the data were first obtained in order to better understand the wide variation exhibited by the initial data. New cores were collected to replace those previously destroyed during analysis. The cores still remaining were recounted. Five minute count times were used since some of the cores did not have high activity levels. Shielded and unshielded measurements were taken of each core to allow a more accurate background correction for each core. The recounted, reevaluated core data gave a mean total efficiency of 0.130 and a standard deviation of 0.06. The individual, recounted core efficiency values



ranged from a high of 0.25 to a low of less than 0.01. Almost 70% of the efficiency measurements were within one sigma of the mean.

The cores were collected from many areas of the plant as described above. Upon physical examination of the cores it was noted that some cores consisted of bare concrete, some had been painted and the paint surface was well worn, some retained a thin coat of paint, and some had been painted with a thick coat of easy-to-decontaminate paint with coatings as thick as 3/32 of an inch. It appears that most of the very low efficiency values came from cores taken in areas where floors were coated with the thick, easy to decontaminate paint. Applying the paint attenuation equation given in NUREG-1507, the thick floor coating would shield the beta particles to the point of almost no detector response. These cores represent areas (RCA floor, Spray Bldg. floor, and Decon Room floor) that will not be amenable to direct measurement by gas-filled detector unless paint is removed. These areas will be surveyed by volumetric sample or in-situ gamma spectroscopy (if justified in technical basis document), or the surface will be remediated before survey. These samples have been removed from the core population in the final  $E_t$  calculation.

The cores with the high efficiencies were evaluated to determine if the presence of high levels of naturally occurring beta particles in the concrete mixture may be contributing to the high values. The background correction that was performed on these samples was for area background, not material background. Material background did not contribute significantly to the sample activity.

The use of gross beta counting is a reasonable, cost effective method for measuring concrete contamination. This technique can also be conservatively applied to activity measurements of the Containment wall liner because the liner is a smooth, nearly flat surface. The alternatives to gross counting (e.g., volumetric sampling with gamma spectrum analysis or in-situ gamma spectroscopy), while admittedly more costly and time consuming survey methods, are viable alternatives. Such measures may be applied to areas with thick floor coatings or very irregular surfaces resulting from remediation activities if an acceptable efficiency correction factor cannot be determined.

The table below lists the instrument, source and total efficiencies for the instruments proposed for material scan and direct measurements.

<b>Table 5-5</b> <b>Survey Instrument Efficiencies</b> (Material Scan and Direct Measurement Instruments)			
<b>Detector</b>	<b>Source Efficiency (<math>E_s</math>)</b>	<b>Total Efficiency (<math>E_t</math>)</b>	<b>Instrument Efficiency (<math>E_i</math>)</b>
Ludlum 43-68	0.389	0.13	0.333
SHP-360	0.225	0.060	0.280

g. Pipe Survey Instrumentation

Remaining pipe will be surveyed to ensure residual remaining activity is less than the DCGL. Pipe crawlers (survey instruments) proposed for use for surveys of pipe with diameters between 1.5 and 12 inches have been shown to have 4 $\pi$  efficiencies ranging from 0.005 to 0.295 respectively. This equates to detection sensitivities of 2800 dpm/100cm<sup>2</sup> to 210 dpm/100cm<sup>2</sup> respectively. This level of sensitivity is adequate to detect residual activity below the BOP embedded pipe DCGL of 100,000 dpm/100cm<sup>2</sup> (800,000 dpm/100cm<sup>2</sup> for spray pipe DCGL) or the buried pipe DCGL of 9,800 dpm/100cm<sup>2</sup>.

The Pipe Explorer<sup>TM</sup> has been selected to survey the embedded Spray Building pipe. The Pipe Explorer<sup>TM</sup> system has been used for alpha, beta, gamma and video surveys of over 6,000 feet of piping. The surveys have included pipes with up to 8 elbows and with vertical runs in excess of 9 m. Detectors have been successfully deployed past rocks, oil, and other debris that have obstructed up to 50 percent of the pipe's cross sectional area. The Pipe Explorer<sup>TM</sup> deployment system is capable of conducting surveys in pipes with diameters ranging from 0.05 m to 1.22 m and survey lengths that vary from 30 m up to 300 m. The detectors are protected and propelled by a pneumatically-driven tubular membrane.

The MDA for the 16 inch spray pipe for example is based on Type 1 and 2 errors of 0.05 and is calculated using the Currie (1968) formula as follows:

$$MDA = \frac{2.71 + 4.65\sqrt{(BKR)(t)}}{(CF)(t)} \text{ where MDA is in dpm/100 cm}^2, \text{ BKR is the}$$

Background Count Rate (cpm), CF is the Conversion Factor in net cpm/dpm/100 cm<sup>2</sup> and t is the count time in minutes. For a background count rate of 4194 counts per minute and a CF of 6.4E-2 cpm/dpm/100cm<sup>2</sup>, an MDA for Cs-137 of 4745 dpm/100cm<sup>2</sup> was calculated.

<b>Table 5-6</b> <b>Measurement Detection Sensitivities**</b>					
<b>Type of Measurement</b>	<b>Detector</b>	<b>Background*</b>	<b>E*** (c/d)</b>	<b>MDC</b>	<b>DCGL</b>
Beta-Gamma Surface Scan	Pancake G-M (SHP-360 )	40 cpm	0.06	10484 dpm/100 cm <sup>2</sup>	18000 dpm/100 cm <sup>2</sup>
Beta-Gamma Surface Scan	Ludlum 43-68 126 cm <sup>2</sup> Gas Proportional	600 cpm	0.13	1832 dpm/100 cm <sup>2</sup>	18000 dpm/100 cm <sup>2</sup>
Beta-Gamma Juncture Scan	Ludlum 43-68 126 cm <sup>2</sup> Gas Proportional	600 cpm	0.06	3969 dpm/100 cm <sup>2</sup>	18000 dpm/100 cm <sup>2</sup>
Beta-Gamma Direct	Pancake G-M (SHP-360 )	40 cpm	0.06	3554 dpm/100 cm <sup>2</sup>	18000 dpm/100 cm <sup>2</sup>
Beta-Gamma Direct	Ludlum 43-68 126 cm <sup>2</sup> Gas Proportional	600 cpm	0.13	714 dpm/100 cm <sup>2</sup>	18000 dpm/100 cm <sup>2</sup>
Beta-Gamma Direct	Ludlum 43-37 582 cm <sup>2</sup> Gas Proportional	2000 cpm	0.141	257 dpm/100 cm <sup>2</sup>	18000 dpm/100 cm <sup>2</sup>
Beta-Gamma Surface Scan	Ludlum 43-37 582 cm <sup>2</sup> Gas Proportional	2000 cpm	0.141	3585 dpm/100 cm <sup>2</sup>	18000 dpm/100 cm <sup>2</sup>
Beta-Gamma Direct	Ludlum 43-94 39 cm <sup>2</sup> Gas Proportional	75 cpm	0.024 (for 3" pipe) 0.031 (for 2" pipe) 0.036 (for 1" pipe)	4305 dpm/100 cm <sup>2</sup> (for Eff. of 0.024)	100,000 dpm/100 cm <sup>2</sup>
Alpha Direct	Ludlum 43-68 126 cm <sup>2</sup> Gas Proportional	1 cpm	0.20	30 dpm/100 cm <sup>2</sup>	Beta-Gamma Direct

<p align="center"><b>Table 5-6</b> <b>Measurement Detection Sensitivities**</b></p>					
<b>Type of Measurement</b>	<b>Detector</b>	<b>Background*</b>	<b>E*** (c/d)</b>	<b>MDC</b>	<b>DCGL</b>
Gamma Scan (Soil)	NaI(Tl) (SPA-3)	10,000 cpm	0.012	5.9 pCi/g (Cs-137)	2.39 pCi/g (Inside RA) 4.2 pCi/g (Outside RA) (Cs equiv.)
Gamma Scan (Concrete)	NaI(Tl) (SPA-3)	20,000 cpm	TBD	See Ref. 5.12.34	18000 dpm/100 cm <sup>2</sup>
Gamma Spectroscopy	HP Ge	N/A	N/A	0.01 pCi/g	2.39 pCi/g (Inside RA) 4.2 pCi/g (Outside RA) (Cs equiv.)
Liquid Beta	Beckman Liquid Scintillation	40 dpm	0.46	3.25E-6 uCi/ml	N/A
Smear Alpha / Beta-Gamma	Tennelec Gas Proportional	0.5 cpm Alpha 30 cpm Beta- gamma	0.25 Alpha 0.35 Beta	25 dpm - alpha  81 dpm - beta- gamma	N/A

\*Background values are typical values. These background values are well below the MDCs and are adequate for selecting the instruments for performing surveys. \*\*The table values are based on a one minute direct count or a surface scan rate of 2 inches per second, and a soil scan rate of 20 sec/m<sup>2</sup>, unless otherwise noted. \*\*\* Efficiencies for concrete surfaces are E<sub>p</sub>. E<sub>p</sub>, adjusted for geometry effects, is used for pipe survey efficiency.

## 5.6 Investigation Levels and Elevated Areas Test

During survey unit measurements, levels of radioactivity may be identified by an increase in count rate, an instrument alarm or an elevated sample result that warrant investigation. Elevated measurements may result from either discrete particles, a distributed source, or a change in background activity. In either case the investigations actions would be followed. Depending on the results of the investigation, the survey unit may require no action, may require remediation, and/or may require reclassification and resurvey. Investigation levels and the investigation process are described below.

#### 5.6.1 Investigation Levels

NUREG 1727 (Table E.2) and NUREG 1575 (Table 5.8) provide investigation levels for scan surveys. In addition to investigation levels for scan surveys, direct measurement survey investigation levels have also been developed. These additional investigation levels include a very conservative value for Class 3 survey units as shown in Table 5-7.

#### 5.6.2 Investigation Process

Technicians will respond to all instrument alarms while surveying. Upon receiving an alarm, the technician will stop and resurvey the last square meter of area to verify the alarm. Technicians are cautioned, in training, about the importance of the alarm verification survey, instructed on expected instrument response to localized areas of elevated activity and are given specific direction in procedure as to survey extent and scan speed. If the alarm is verified, the technician will mark the area with a flag or other appropriate means. The alarm data may be evaluated by the FSSS with respect to the investigation levels specified in Table 5-7. Each area marked, which exceeds the investigation level specified in Table 5-7, will have an investigation survey instruction prepared. The instruction will require a re-scan of the area, direct measurements, field gamma spectroscopy measurement (as appropriate), and collection of a soil sample (for land surveys). Each investigation will be evaluated and reported in the survey unit Release Record.

The size and average activity level in the elevated area is determined to demonstrate compliance with the area factors. If any location in a Class 2 area exceeds the DCGL, scanning coverage in the vicinity is increased in order to determine the extent and level of the elevated reading(s). If the elevated reading occurs in a Class 3 area, the scanning coverage is increased and the area should be reclassified.

Table 5-7 Investigation Levels		
Classification	Scan Investigation Levels <sup>6</sup>	Direct Investigation Levels
Class 1	$>DCGL_{EMC}$	$>DCGL_{EMC}$
Class 2	$>DCGL_w$ or $>MDC_{scan}$ if $MDC_{scan}$ is greater than $DCGL_w$ .	$>DCGL_w$
Class 3	$>DCGL_w$ or $>MDC_{scan}$ if $MDC_{scan}$ is greater than $DCGL_w$ .	$>0.5 DCGL_w$

Investigations should consider: (1) the assumptions made in the survey unit classification; (2) the most likely or known cause of the contamination; and (3) the possibility that other areas within the survey unit may have elevated areas of activity that may have gone undetected. Depending on the results of the investigation, a portion of the survey unit may be reclassified if there is sufficient justification. The results of the investigation process are documented in the survey area Release Record. See also Section 5.6.4 for additional discussion regarding potential reclassification of the survey unit.

### 5.6.3 Elevated Measurement Comparison (EMC)

The elevated measurement comparison may be used for Class 1 survey units when one or more scan or static measurements exceed the investigation level if remediation is not performed. The EMC provides assurance that unusually large measurements receive the proper attention and that any area having the potential for significant dose contribution is identified. As stated in NUREG-1575, the EMC is intended to flag potential failures in the remediation process and should not be considered the primary means to identify whether or not a survey unit meets the release criterion.

Locations identified by scan with levels of residual radioactivity which exceed the *a priori*  $DCGL_{EMC}$  or static measurements with levels of residual radioactivity which exceed the *a priori*  $DCGL_{EMC}$  are subject to additional surveys to determine compliance with the elevated measurement criteria. The size of the area containing the elevated residual radioactivity and the average level of residual activity within the area are determined. The average level of activity is compared to the  $DCGL_w$  based on the actual area of elevated activity. (If a background reference area is being applied to the survey unit, the mean of the background reference area activity may be subtracted before conducting the EMC).

<sup>6</sup> Must be calculated *a priori*. The *a priori*  $DCGL_{EMC}$  for soil was calculated to be 5.9 pCi/g in accordance with Section 5.5.6.d.

The *a priori*  $DCGL_{EMC}$  is established during the survey design and is calculated as follows:

$$DCGL_{EMC} = \text{Area Factor} \times DCGL$$

The area factor is the multiple of the DCGL that is permitted in the area of elevated residual radioactivity without remediation. The area factor is related to the size of the area over which the elevated activity is distributed. That area is generally bordered by levels of residual radioactivity below the DCGL and is determined by the investigation process. Area factors are calculated in Section 6 of the LTP and listed in Tables 6-12 and 6-14.

The actual area of elevated activity is determined by investigation surveys and the area factor is adjusted for the actual area of elevated activity. The product of the adjusted area factor and the  $DCGL_w$  determines the actual  $DCGL_{EMC}$ . If the  $DCGL_{EMC}$  is exceeded, the area is remediated and resurveyed.

The results of the elevated area investigations in a given survey unit that are below the  $DCGL_{EMC}$  limit are evaluated using the equation below. If more than one elevated area is identified in a given survey unit, the unity rule can be used to determine compliance. If the formula value is less than unity, no further elevated area testing is required and the EMC test is satisfied.

$$\frac{\delta}{DCGL_w} + \frac{(\text{average concentration in elevated area} - \delta)}{(\text{Area Factor})(DCGL_w)} < 1$$

Where:  $\delta$  is the average residual activity in the survey unit. When calculating  $\delta$  for use in this inequality, measurements falling within the elevated area may be excluded provided the overall average in the survey unit is less than the  $DCGL_w$ .<sup>7</sup> For contaminated concrete (basement fill model), the area factor used in the unity rule may be specified as the survey unit size divided by the elevated area size.

Compliance with the soil  $DCGL_{EMC}$  will be determined using the FSS gamma spectroscopy results and a unity rule approach. These general methods will also be applied to other materials where sample gamma spectroscopy is used for FSS. The application of the unity rule to the elevated measurement comparison requires area factors and corresponding  $DCGL_{EMC}$ 's to be calculated for Cs-137, Co-60, and any other gamma emitter identified during FSS, separately.

The methods used to calculate the nuclide specific soil area factors will be the same as described in Section 6.8.2. These area factors are used to determine  $DCGL_{EMC}$  for Co-60,

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<sup>7</sup> MARSSIM, NUREG-1575, Revision 1, (June 2001), Section 8.5.2, per the EPA website at [www.epa.gov/radiation/marssim/docs/revision1](http://www.epa.gov/radiation/marssim/docs/revision1).

Cs-137, and any other identified gamma emitter, for each elevated area being evaluated during FSS. The surrogate radionuclides will be conservatively accounted for through the application of the Cs-137 area factor to the surrogate Cs-137 DCGL since the HTD radionuclides have higher area factors than Cs-137. The  $DCGL_{EMC}$ 's are used as follows to determine compliance with the elevated measurement comparison. Background could be subtracted from each radionuclide concentration if necessary.

$$\left( \frac{Cs - 137}{Cs - 137_{DCGL_{EMC}}} \right) + \left( \frac{Co - 60}{Co - 60_{DCGL_{EMC}}} \right) + \dots + \left( \frac{R_N}{DCGL_{EMC_N}} \right) \leq 1.0$$

Where: Cs-137 and Co-60 are the gamma spec results from FSS,

$DCGL_{EMC_N}$  is calculated for the size of the elevated area being evaluated,

$R_N$  is any other gamma emitter identified during FSS, and

$DCGL_{EMC_N}$  is the  $DCGL_{EMC}$  for radionuclide N

#### 5.6.4 Remediation and Reclassification

As shown in Table 5-8, for any classification (1, 2 or 3), areas of elevated residual activity above the  $DCGL_{EMC}$  are remediated to reduce the residual radioactivity to acceptable levels. Whenever an investigation confirms activity above an action level listed in Table 5-8, an evaluation of the HSA, operational history, design information, and sample results will be performed. The evaluation will consider: (1) the elevated area's location, dimensions, and sample results, (2) an explanation as to the potential cause and extent of the elevated area in the survey unit, (3) the recommended extent of reclassification, if considered appropriate, and (4) any other required actions. Areas that are reclassified as Class 1 are typically bounded by a Class 2 buffer zone to provide further assurance that the reclassified area completely bounds the elevated area. This evaluation process is established to avoid the unwarranted reclassification of an entire survey unit (which can be quite large) while at the same time requiring an assessment as to extent and reasons for the elevated area.

Specifically, for the reclassification (following LTP approval) of a survey unit (or portion of a survey unit) from Class 1 to Class 2, the following criteria will be followed:

1. The survey unit (or portion of a survey unit) to be reclassified as Class 2 must meet the Class 2 designation (LTP Section 5.2.2), i.e., prior to remediation, the reclassified area is not likely to contain residual radioactivity in excess of the  $DCGL_w$ .



2. There is sufficient knowledge regarding the distribution of contamination within the reclassified Class 2 area to support a conclusion that subject area is not likely to contain residual radioactivity in excess of the DCGL<sub>w</sub>.
3. As noted in Table 5-3, for Class 2 Survey Units, the amount of scan coverage will be proportional to the potential for finding areas of elevated activity or areas close to the release criterion in accordance with MARSSIM Section 5.5.3.

Reclassification from either Class 1 or Class 2 to Class 3 would generally observe similar criteria as listed above.

1. The reclassified survey unit (or portions thereof) would be required to meet Class 3 requirements (per Section 5.2.2).
2. There is sufficient knowledge regarding the distribution of contamination within the reclassified Class 3 area to support a conclusion that the area has a low probability of containing residual radioactivity.
3. Scan coverage for the reclassified area will meet Table 5-3 requirements

Per agreements with NRC, Maine Yankee will provide notification to the NRC prior to a reclassification (following LTP approval) of a survey unit (or portion of a survey unit) per the discussion in Section 1.4.

If an individual survey measurement (scan or direct) in a Class 2 survey unit exceeds the DCGL, the survey unit or a portion of it may be reclassified and the survey redesigned and re-performed accordingly. If an individual survey measurement in a Class 3 survey unit exceeds 0.5 DCGL, the survey unit, or portion of a survey unit, will be evaluated, and if necessary, reclassified to a Class 2 and the survey redesigned and re-performed accordingly.

Table 5-8 Investigation Actions			
Action If Investigation Results Exceed:			
Class	DCGL <sub>EMC</sub>	DCGL <sub>w</sub>	0.5 DCGL <sub>w</sub>
1	Remediate and resurvey as necessary	Acceptable	Acceptable
2	Remediate, reclassify portions as necessary	Reclassify portions as necessary	Acceptable
3	Remediate, reclassify portions as necessary	Increase scan coverage and reclassify portions as necessary	Increase scan coverage and reclassify portions as necessary

### 5.6.5 Resurvey

Following an investigation, if a survey unit is reclassified or if remediation activities were performed, a resurvey is performed in accordance with procedures. If a Class 2 area had contamination greater than the DCGL<sub>w</sub> it should be reclassified. If the average value of Class 2 direct survey measurements was less than the DCGL<sub>w</sub>, the Scan<sub>MDC</sub> was sensitive enough to detect the DCGL<sub>EMC</sub> and there were no areas greater than the DCGL<sub>EMC</sub>, the survey redesign may be limited to obtaining a 100% scan without having to re-perform the direct measurements. This condition assumes that the sample density meets the requirements for a Class 1 area. If the Class 2 area had contamination greater than the DCGL<sub>w</sub>, but the Scan<sub>MDC</sub> was not sensitive enough to detect the DCGL<sub>EMC</sub>, the affected area is reclassified and resurveyed at the sample density determined from the EMC.

## 5.7 Data Collection and Processing

### 5.7.1 Sample Handling and Record Keeping

A sample tracking record (chain-of-custody record) accompanies each sample from the point of collection through obtaining the final results to ensure the validity of the sample data. Sample tracking records are controlled and maintained and, upon completion of the data cycle, are transferred to Document Control, in accordance with applicable procedures.

Each survey unit has a document package associated with it which covers the design and field implementation of the survey requirements. Survey unit records are quality records.

### 5.7.2 Data Management

Survey data are collected from several sources during the data life cycle and are evaluated.

QC replicate measurements are not used as final status survey data. See LTP Section 5.10.4(d) for design and use of QC replicate measurements.

Measurements performed during turnover and investigation surveys can be used as final status survey data if they were performed according to the same requirements as the final survey data. These requirements include: (1) the representativeness of the survey data to reflect the as-left survey unit condition untouched by further remediation; (2) the application of isolation measures to the survey unit to prevent re-contamination and to maintain final configuration; and (3) the data collection and design were in accordance with FSS methods, e.g., scan MDC, investigation levels, survey data point number and location, statistical tests, and EMC tests.

Measurement results stored as final status survey data constitute the final survey of record and are included in the data set for each survey unit used for determining compliance with the site release criteria.

Measurements are recorded in units appropriate for comparison to the DCGL. The recording units for surface contamination are dpm/100 cm<sup>2</sup> and pCi/g for activity concentrations. Numerical values, even negative numbers, are recorded.

Document Control procedures establish requirements for record keeping. Measurement records include, at a minimum, the surveyor's name, the location of the measurement, the instrument used, measurement results, the date and time of the measurement and any surveyor comments.

### 5.7.3 Data Verification and Validation

The final status survey data are reviewed before data assessment to ensure that they are complete, fully documented and technically acceptable. The review criteria for data acceptability will include at a minimum, the following items:

- a. The instrumentation MDC for fixed or volumetric measurements was below the DCGL<sub>w</sub> or if no, it was below the DCGL<sub>EMC</sub> for Class 1, below the DCGL<sub>w</sub> for Class 2 and below 0.5 DCGL<sub>w</sub> for Class 3 survey units.
- b. The instrument calibration was current and traceable to NIST standards,
- c. The field instruments were source checked with satisfactory results before and after use each day data were collected or data was evaluated by the

FSSE if instruments did not pass a source check in accordance with 5.5.2.c

- d. The MDCs and assumptions used to develop them were appropriate for the instruments and techniques used to perform the survey,
- e. The survey methods used to collect data were proper for the types of radiation involved and for the media being surveyed,
- f. "Special methods" for data collection were properly applied for the survey unit under review. These special methods are either described in this LTP section or will be the subject of an NRC notice of opportunity for review,
- g. The chain-of-custody was tracked from the point of sample collection to the point of obtaining results,
- h. The data set is comprised of qualified measurement results collected in accordance with the survey design which accurately reflect the radiological status of the facility, and
- i. The data have been properly recorded.

If the data review criteria were not met, the discrepancy will be reviewed and the decision to accept or reject the data will be documented in accordance with approved procedures.

#### 5.7.4 Graphical Data Review

Survey data may be graphed to identify patterns, relationships or possible anomalies which might not be so apparent using other methods of review. A posting plot or a frequency plot may be made. Other special graphical representations of the data will be made as the need dictates.

##### a. Posting Plots

Posting plots may be used to identify spatial patterns in the data. The posting plot consists of the survey unit map with the numerical data shown at the location from which it was obtained. Posting plots can reveal patches of elevated radioactivity or local areas in which the DCGL is exceeded. Posting plots can be generated for background reference areas to point out spatial trends that might adversely affect the use of the data. Incongruities in the background data may be the result of residual, undetected activity, or they may just reflect background variability.

b. Frequency Plots

Frequency plots may be used to examine the general shape of the data distribution. Frequency plots are basically bar charts showing data points within a given range of values. Frequency plots reveal such things as skewness and bimodality (having two peaks). Skewness may be the result of a few areas of elevated activity. Multiple peaks in the data may indicate the presence of isolated areas of residual radioactivity or background variability due to soil types or differing materials of construction. Variability may also indicate the need to more carefully match background reference areas to survey units or to subdivide the survey unit by material or soil type.

5.8      Data Assessment and Compliance

An assessment is performed on the final status survey data to ensure that they are adequate to support the determination to release the survey unit. Simple assessment methods such as comparing the survey data to the DCGL or comparing the mean value to the DCGL are first performed. The statistical tests are then applied to the final data set and conclusions are made as to whether the survey unit meets the site release criterion.

5.8.1 Data Assessment Including Statistical Analysis

The results of the survey measurements are evaluated to determine whether the survey unit meets the release criterion. In some cases, the determination can be made without performing complex, statistical analyses.

a. Interpretation of Sample Measurement Results

An assessment of the measurement results is used to quickly determine whether the survey unit passes or fails the release criterion or whether one of the statistical analyses must be performed. The evaluation matrices are presented in Tables 5-9 and 5-10.

<b>Table 5-9</b> <b>Interpretation of Sample Measurements When WRS Test Is Used</b>	
<b>Measurement Results</b>	<b>Conclusion</b>
Difference between maximum survey unit concentration and minimum reference area concentration is less than DCGLw	Survey unit meets release criterion.
Difference of survey unit average concentration and reference average concentrations greater than DCGLw	Survey unit fails.
Difference between any survey unit concentration and any reference area concentration is greater than DCGLw and the difference of survey unit average concentration and reference area average concentration is less than DCGLw	Conduct WRS test and elevated measurements test.

<b>Table 5-10</b> <b>Interpretation of Sample Measurements When Sign Test is Used</b>	
<b>Measurement Results</b>	<b>Conclusion</b>
All concentrations less than DCGLw	Survey unit meets release criterion
Average concentration greater than DCGLw	Survey unit fails
Any concentration greater than DCGLw and average concentration less than DCGLw	Conduct Sign Test and elevated measurements test.

When required, one of four statistical tests will be performed on the survey data:

1. WRS Test
2. Sign Test
3. WRS Test Unity Rule
4. Sign Test Unity Rule

In addition, survey data are evaluated against the EMC criteria as previously described in Section 5.6.3 and as required by NUREG 1727. The statistical test is based on the null hypothesis (H<sub>0</sub>) that the residual radioactivity in the survey unit exceeds the DCGL. There must be sufficient survey data at or below the DCGL to reject the null hypothesis and conclude the survey unit meets the site release criterion for dose. Statistical analyses are performed using a specially designed software package or, if necessary, using hand calculations.

b. Wilcoxon Rank Sum Test

The WRS test, or WRS Unity Rule (NUREG-1505, Chapter 11), may be used when the radionuclide of concern is present in the background or measurements are used that are not radionuclide-specific. In addition, this test is valid only when "less than" measurement results do not exceed 40 percent of the data set.

The WRS test is applied as follows:

1. The background reference area measurements are adjusted by adding the  $DCGL_w$  to each background reference area measurement,  $X_i$ ,  $Z_i = X_i + DCGL$ .
2. The number of adjusted background reference area measurements,  $m$ , and the number of survey unit measurements,  $n$ , are summed to obtain  $N$ , ( $N = m + n$ ).
3. The measurements are pooled and ranked in order of increasing size from 1 to  $N$ . If several measurements have the same value, they are assigned the average rank of that group of measurements.
4. The ranks of the adjusted background reference area measurements are summed to obtain  $W_r$ .
5. The value of  $W_r$  is compared with the critical value in Table I.4 of NUREG-1575. If  $W_r$  is greater than the critical value, the survey unit meets the site release dose criterion. If  $W_r$  is less than or equal to the critical value, the survey unit fails to meet the criterion.

c. Sign Test

The Sign test and Sign test Unity Rule are one-sample statistical tests used for situations in which the radionuclide of concern is not present in background, or is present at acceptable low fractions compared to the  $DCGL_w$ . If present in background, the gross measurement is assumed to be entirely from plant activities. This option is used when it can be reasonably expected that including the background concentration will not affect the outcome of the Sign test. The advantage of using the Sign test is that a background reference area is not needed. The Sign Test may also be used with background subtraction in accordance with Chapter 12 of NUREG-1505.

The Sign test is conducted as follows:

1. The survey unit measurements,  $X_i$ ,  $i = 1, 2, 3, \dots, N$ ; where  $N$  = the number of measurements, are listed.
2.  $X_i$  is subtracted from the  $DCGL_w$  to obtain the difference  $D_i = DCGL_w - X_i$ ,  $i = 1, 2, 3, \dots, N$ .
3. Differences where the value is exactly zero are discarded and  $N$  is reduced by the number of such zero measurements.
4. The number of positive differences are counted. The result is the test statistic  $S^+$ . Note that a positive difference corresponds to a measurement below the  $DCGL_w$  and contributes evidence that the survey unit meets the site release criterion.
5. The value of  $S^+$  is compared to the critical value given in Table I.3 of NUREG-1575. The table contains critical values for given values of  $N$  and  $\alpha$ . The value of  $\alpha$  is set at 0.05 during survey design. If  $S^+$  is greater than the critical value given in the table, the survey unit meets the site release criterion. If  $S^+$  is less than or equal to the critical value, the survey unit fails to meet the release criterion.

#### d. Unity Rule

The Cs-137 to Co-60 ratio will vary in the final survey soil samples, and this will be accounted for using a "unity rule" approach as described in NUREG-1505 Chapter 11. Unity Rule Equivalents will be calculated for each measurement result using the surrogate adjusted Cs-137 DCGL and the adjusted Co-60 DCGL, as shown in the following equation. (See Section 6.7.2 for the Cs-137<sub>s</sub> DCGL calculation.)

$$\text{Unity Rule Equivalent} \leq 1 = \frac{\text{Cs-137}}{DCGL_{(Cs-137_s)}} + \frac{\text{Co-60}}{DCGL_{(Co-60_A)}} + \dots + \frac{R_N}{DCGL_{(N_A)}}$$

Where: Cs-137 and Co-60 are the gamma spec results,

$DCGL_{(Cs-137_s)}$  is the surrogate Cs-137s DCGL, adjusted

to represent the Table 6-11 total surface dose, as applicable (inside RA)



$DCGL_{(Co-60_A)}$  is the Co-60 DCGL, adjusted to represent the Table 6-11 total surface dose, as applicable (inside RA)

$R_N$  is any other identified gamma emitting radionuclides, and  
 $DCGL_{(N_A)}$  is the adjusted DCGL for radionuclide N.

The unity rule equivalent results will be used to demonstrate compliance assuming the DCGL is equal to 1.0 using the criteria listed in the LTP, Tables 5-9 and 5-10. If the application of the WRS or Sign test is necessary, these tests will be applied using the unity rule equivalent results and assuming that the DCGL is equal to 1.0. An example of a WRS test using the unity rule is provided in NUREG-1505, Page 11-3, Section 11.4. If the WRS test is used, or background subtraction is used in conjunction with the Sign test, background concentrations will also be converted to Unity Rule Equivalents prior to performing test.

The Sign test will be used without background subtraction if background Cs-137 is not considered a significant fraction of the DCGL. Note that the surrogate Cs-137 DCGL will be used for both the statistical tests and comparisons with the criteria in LTP Tables 5-9 and 5-10.

The same general surrogate and unity rule methods described above for soil will be applied to other materials, such as activated concrete, where sample gamma spectroscopy is used for final survey as opposed to gross beta measurements.

#### 5.8.2 Data Conclusions

The results of the statistical tests, including application of the EMC, allow one of two conclusions to be made. The first conclusion is that the survey unit meets the site release dose criterion. The data provide statistically significant evidence that the level of residual radioactivity in the survey unit does not exceed the release criterion. The decision to release the survey unit is made with sufficient confidence and without further analysis.

The second conclusion that can be made is that the survey unit fails to meet the release criterion. The data are not conclusive in showing that the residual radioactivity is less than the release criterion. The data are analyzed further to determine the reason for the failure.

Possible reasons are that:

1. the average residual radioactivity exceeds the DCGL, or

2. the test did not have sufficient power to reject the null hypothesis (i.e., the result is due to random statistical fluctuation).

The power of the statistical test is a function of the number of measurements made and the standard deviation in measurement data. The power is determined from  $1-\beta$  where  $\beta$  is the value for Type II errors. A retrospective power analysis may be performed using the methods described in Appendices I.9 and I.10 of NUREG-1575. If the power of the test is insufficient due to the number of measurements, additional samples may be collected as directed by procedure. A greater number of measurements increases the probability of passing if the survey unit actually meets the release criterion. If failure was due to the presence of residual radioactivity in excess of the release criterion, the survey unit must be remediated and resurveyed.

### 5.8.3 Compliance

The final status survey is designed to demonstrate that licensed radioactive materials have been removed from MY station facilities and property to the extent that residual levels of radioactive contamination are below the radiological criteria for unrestricted use as approved by the NRC. The site-specific radiological criteria presented in this plan demonstrate compliance with the criteria of 10CFR20.1402 and State of Maine Law LD 2688-SP1084.

If the measurement results pass the requirements of Tables 5-9 and 5-10 of Section 5.8.1, and the elevated areas evaluated per Section 5.6.3 pass the elevated measurement comparison, then the survey unit is suitable for unrestricted release.

## 5.9 Reporting Format

Survey results are documented in history files, survey unit release records, and in the final status survey report. Other reports may be generated as requested by the NRC.

### 5.9.1 History File

A history file of relevant operational and decommissioning data has been compiled. The history file consists of the HSA, GTS Characterization Report, Classification Basis, and 50.75(g) file information. The purpose of the history file is to provide a substantive basis for the survey unit classification, and hence, the level of intensity of the final status survey. The history file contains:

1. Operating history which could affect radiological status
2. Summarized scoping and site characterization data

### 3. Other relevant information

#### 5.9.2 Survey Unit Release Record

A separate release record is prepared for each survey unit. The survey unit release record is a document containing sufficient information necessary to demonstrate compliance with the site release criteria. This record includes at least:

- a. Description of the survey unit
- b. Survey unit design information
- c. Survey results
- d. Survey unit investigations performed and their results
- e. Survey unit data assessment results

When a survey unit release record is given final approval it becomes a quality record.

#### 5.9.3 Final Status Survey Report

Survey results will be described in a written report to the NRC. The actual structures, land, or piping system included in each written report may vary depending on the status of ongoing decommissioning activities.

The final status survey report provides a summary of the survey results and the overall conclusions which demonstrate that the MY facility and site meet the radiological criteria for unrestricted use. Information such as the number and type of measurements, basic statistical quantities, and statistical analysis results are included in the report. The level of detail is sufficient to clearly describe the final status survey program and to certify the results. The format of the final report will contain the following topics:

- 1.0 Overview of the Results
- 2.0 Discussion of Changes to FSS
- 3.0 Final Status Survey Methodology
  - Survey unit sample size
  - Justification for sample size
- 4.0 Final Status Survey Results

- Number of measurements taken
- Survey maps
- Sample concentrations
- Statistical evaluations, including power curves
- Judgmental and miscellaneous data sets
- Investigations and results (anomalous data)

#### 5.0 Conclusion for each survey unit

- Any Changes from initial assumptions on extent of residual activity.
- Simplified General Retrospective Dose Estimate: For illustrative purposes, relevant FSS data will be reviewed to determine a gross average of residual contamination level which will be used to calculate a retrospective dose estimate. This retrospective dose estimate, which will be provided in the final report, may be helpful in illustrating to various stakeholders Maine Yankee's compliance with the dose based release criteria.

#### 5.9.4 Other Reports

Other reports will be prepared and submitted as requested.

#### 5.10 FSS Quality Assurance Plan (QAP)

The Final Status Survey QAP, as described in this section, is developed and implemented by trained and qualified personnel. The FSS QAP will ensure that the site will be surveyed, evaluated and determined to be acceptable for unrestricted use if the residual activity results in an annual TEDE to the average member of the critical group of 10 mrem/year or less for all pathways and 4 mrem or less for groundwater drinking sources (enhanced state clean-up levels). Ensuring that the site meets the requirements for license termination is a complex process. Quality must be built in to each phase of the plan and measures must be taken during the execution of the plan to determine whether the expected level of quality is being achieved.

The Quality Assurance activities for decommissioning are based on the requirements of 10CFR50.82. The objective of the FSS QAP is to ensure that the survey data collected are of the type and quality needed to demonstrate with sufficient confidence that the site is suitable for unrestricted release. The objective is met through use of the DQO process for FSS design, analysis and evaluation. The plan ensures that: 1) the elements of the final status survey plan are implemented in accordance with the approved procedures; 2) surveys are conducted by trained personnel using calibrated instrumentation; 3) the quality of the data collected is adequate; 4) all phases of package design and survey are properly reviewed, and oversight is

provided; and 5) corrective actions, when identified, are implemented in a timely manner and are determined to be effective. The FSS QA Plan will be applied to the following aspects of final status survey activities.

#### 5.10.1 Project Management and Organization

An FSS project organization will be established when the ISFSI areas are to be decommissioned. It will be similar to the FSS organization described below.

The FSS project organization was established within the Maine Yankee radiation protection organization for planning and implementation of the final status surveys of the areas associated with the Maine Yankee Nuclear Plant. This organization, depicted in Figure 5-6 (at end of Section 5), was directed by the Manager of Projects - FSS who reported to the Radiation Protection Manager (RPM). The RPM maintained overall responsibility for the performance of the final status survey and overall integration of the FSS project with other decommissioning activities<sup>8</sup>.

The Final Status Survey project organization consisted of the following functional levels:

- a. **Manager of Projects (MOP) - FSS:** The Manager of Projects for Final Status Survey (MOP FSS) was responsible for the administration of, and ensuring the implementation of, the FSS Plan. The MOP FSS was responsible for ensuring activities conducted as part of the FSS were performed in accordance with the FSS Quality Assurance Plan. The MOP FSS was responsible for management of personnel assigned to the FSS section. The MOP FSS was responsible for approving FSS Release Records and ensuring contractual and licensing obligations were satisfied. The MOP FSS reported to the RPM.
- b. **Superintendent of Radiation Remediation (SRR):** The SRR had the overall responsibility for the planning, monitoring and coordination of radiological remediation in preparation for FSS activities. The SRR had responsibility for establishing, maintaining and implementing the programs, procedures and evaluations to support radiological remediation. The SRR had responsibility for the pre-demolition surveys of structures being demolished as well as the control of radioactive material resulting from demolition. The SRR, when directed, had responsibility for Turnover Surveys prior to area acceptance for FSS. The SRR reported to the MOP-FSS.

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<sup>8</sup> See Section 5.10.1 for discussion of the relationship between the FSS project organization and the Maine Yankee Quality Assurance Program

- c. **Superintendent of Final Status Survey (SFSS):** The Superintendent of Final Status Survey (SFSS) was responsible for the preparation and implementation of the FSS program. The SFSS had overall responsibility for program direction, technical content, and ensuring the program complied with applicable NRC regulations and guidance. The SFSS was responsible for resolution of issues or concerns raised by NRC, the State of Maine, or other stakeholders, as well as any programmatic issues raised by Maine Yankee Management. The SFSS provided overall management and direction to FSS personnel. Interface with regulatory agencies and other outside organizations regarding the FSS Program was conducted primarily by the SFSS. The SFSS reviewed and approved the qualification and selection of FSS personnel and approved the content of training to FSS personnel and other personnel on FSS topics. The SFSS approved reports of FSS results. The SFSS reported to the MOP-FSS.
- d. **Radiochemist:** The Radiochemist was responsible for the conduct of the day to day activities performed by Chemistry personnel and for the supervision of the counting room personnel and activities. The Radiochemist was responsible for data quality of onsite FSS sample analyses. (If samples were processed offsite, the MY Quality Assurance Program determined the quality requirements for offsite procurement.) The Radiochemist reported to the Superintendent Radiation Engineering and Technical Support.
- e. **FSS Engineer (FSSE):** The FSS Engineer (FSSE) was responsible for the technical support, development, and implementation of FSS procedures. The FSSE was responsible for the review of survey packages and the review of all data collected in support of the FSSE. The FSSE reviewed FSS procedures and reports of FSS results. The FSSE reported to the SFSS.
- f. **FSS Specialist (FSSS):** The FSSS was responsible for preparation of survey packages for individual survey areas, including history files, survey designs and instructions. In addition, the FSSS was responsible for preparation of survey maps, grid maps, layout diagrams, composite view drawings and other graphics as necessary to support FSS reporting. The FSSS reported to the Superintendent FSS.
- g. **FSS Supervisor:** The FSS Supervisor was responsible for control and implementation of survey packages as received from the FSS Specialist. The FSS Supervisor was responsible for coordination of turnover surveys, final status surveys, and survey area preparation such as gridding and accessibility needs. The FSS Supervisor was responsible for coordination and scheduling of FSS Technicians to support the FSS schedule and ensuring all necessary instrumentation and other equipment is available to

support survey activities. The FSS Supervisor was also responsible for maintaining access controls over completed FSS survey areas. The FSS Supervisor reported to the SFSS.

- h. Instrumentation Technician (IT): The IT was responsible for maintaining the pedigree of instrumentation used for FSS by implementing the procedural requirements for calibration, maintenance and daily checks. The IT ensured that sufficient and properly calibrated instrumentation was available to support FSS. The IT was responsible for the calibration and maintenance of FSS instrumentation. The IT reported to the Instrumentation, Sources and Respiratory Protection Engineer (ISRPE). (The ISRPE's responsibilities included the site RP instrumentation program.)
- i. FSS Technician: The FSS Technician was responsible for performance of FSS measurements and collection of FSS samples in accordance with FSS procedures and survey package instructions. The FSS Technician reported to the FSS Supervisor.
- j. Site Quality and its Relationship to the Maine Yankee Quality Assurance Program.
  - (1) The Maine Yankee Quality Assurance Program has been established as required by, and to assure conformance with, 10CFR50 Appendix B and other regulations relevant to the decommissioning of Maine Yankee.<sup>9</sup>
  - (2) The MY President has overall responsibility for all aspects of the QA Program.
  - (3) The Quality Programs Manager (QPM) has the overall authority and responsibility for establishing and measuring the effectiveness of the Quality Assurance Program. By provisions in the Program, the QPM has direct access to senior management positions.
  - (4) The QPM reports through the Director, Nuclear Safety and Regulatory Affairs, through the Vice President and Chief Financial Officer, who in turn reports to the President).<sup>10</sup>
  - (5) The MY Quality Assurance Program supports the FSS QAP by activities and services related to quality, such as, the establishment of requirements and assessing adequacy of implementation for

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<sup>9</sup> Sections I.B.1 and II.C, MY Quality Assurance Program, May 1, 2002.

<sup>10</sup> The overall MY site organization is illustrated (with QA reporting lines) in Figure 6.1-1 of the MY Defueled Safety Analysis Report (DSAR). As noted in this figure, the QPM has a "functional report" to the President on matters of quality (DSAR Section 6.1.2).

procurement control, procedures and instructions, corrective actions, record retention, and audits/surveillances.

#### 5.10.2 Project Description and Schedule

Each area of the site will be divided into survey units and classified as directed by procedure. The survey measurements for each survey unit will be determined during the survey design phase. Portions of the final status survey will be performed during deconstruction activities as areas become available for survey. The non-impacted areas may be evaluated for release prior to significant decommissioning activities taking place.

#### 5.10.3 Quality Objectives and Measurement Criteria

Type I errors will be established at 0.05 unless authorized by the NRC. Type II errors will be set at 0.05 or greater.

##### a. Training and Qualification

Personnel performing final status survey measurements will be trained and qualified. Training will include the following topics:

- Procedures governing the conduct of the final status survey,
- Operation of field and laboratory instrumentation used in the final status survey, and
- Collection of final status survey measurements and samples.

The extent of training and qualification will be commensurate with the education, experience and proficiency of the individual and the scope, complexity and nature of the activity. Records of training will be maintained in accordance with the approved course description for Initial and Continuing Training for Decommissioning.

##### b. Survey Documentation

Each final status survey measurement will be identified by date, instrument, location, type of measurement, and mode of operation. Generation, handling and storage of the original final status survey design and data packages will be controlled. The FSS records have been designated as quality documents and, as such, they will be maintained as such in accordance with procedures.



#### 5.10.4 Measurement/Data Acquisition

##### a. Survey Design and Sampling Methods

The site will be divided into survey areas. Each survey area package may contain one or more survey units. Each survey area package will specify the type and number of measurements required based on the classification of each survey unit.

##### b. Written Procedures

Sampling and survey tasks must be performed properly and consistently in order to assure the quality of the final status survey results. The measurements will be performed in accordance with approved, written procedures. Approved procedures describe the methods and techniques used for the final status survey measurements.

##### c. Chain of Custody

Responsibility for custody of samples from the point of collection through the determination of the final survey results is established by procedure. When custody is transferred, a chain of custody form will accompany the sample for tracking purposes. Secure storage will be provided for archived samples.

##### d. Quality Control Surveys

Procedures establish built-in Quality Control checks in the survey process for both field and laboratory measurements, as described in LTP Section 5.4.5(f). For structures and systems, QC replicate scan measurements will consist of resurveys of a minimum of 5% of randomly selected class 1, 2, or 3 survey units typically performed by a different technician with results compared to the original measurement. The acceptance criterion shall be that the same conclusion as the original survey was reached based on the repeat scan. If the acceptance criterion is not met, an investigation will be conducted to determine the cause and corrective action.

Quality Control for direct surface contamination and/or exposure rate measurements will consist of repeat measurements of a minimum of 5% of the survey units using the same instrument type, taken by a different technician (except in cases where there is only one instrument or specialized training is required to operate the equipment) and the results compared to the original measurements using the same instrument type. The acceptance

criterion for direct measurements is specified in approved procedures.

For soil, water and sediment samples, Quality Control will consist of participation in the laboratory Inter-comparison Program. However, as an additional quality measure, approximately 5% of such samples may be subjected to blind duplicate samples or third party analyses. The acceptance criterion for blank samples is that no plant-derived radionuclides are detected. The criterion for blind duplicates is that the two measurements are within the value specified by approved procedure. For third party analyses, the acceptance criterion is the same as those for blind duplicates. Some sample media, such as asphalt, will not be subjected to split or blind duplicate analyses due to the lack of homogeneity. These samples will simply be recounted to determine if the two counts are within 20% of each other, when necessary.

If QC replicate measurements or sample analyses fall outside of their acceptance criteria, a documented investigation will be performed in accordance with approved procedures; and if necessary, the Corrective Action Process described in Section 5.10.5(c) will be implemented. The investigation will typically involve verification that the proper data sets were compared, the relevant instruments were operating properly and the survey/sample points were properly identified and located. Relevant personnel are interviewed, as appropriate, to determine if proper instructions and procedures were followed and proper measurement and handling techniques were used including chain of custody, where applicable. When deemed appropriate, additional measurements are taken. Following the investigation, a documented determination is made regarding the usability of the survey data and if the impact of the discrepancy adversely affects the decision on the radiological status of the survey unit.

e. Instrumentation Selection, Calibration and Operation

Proper selection and use of instrumentation will ensure that sensitivities are sufficient to detect radionuclides at the minimum detection capabilities as specified in Section 5.5.2 as well as assure the validity of the survey data. Instrument calibration will be performed with NIST traceable sources using approved procedures. Issuance, control and operation of the survey instruments will be conducted in accordance with the Instrumentation Program procedure.

f. Control of Consumables

In order to ensure the quality of data obtained from FSS surveys and samples, new sample containers will be used for each sample taken. Tools

used to collect samples will be cleaned to remove contamination prior to taking additional samples. Tools will be decontaminated after each sample collection and surveyed for contamination.

**g. Control of Vendor-Supplied Services**

Vendor-supplied services, such as instrument calibration and laboratory sample analysis, will be procured from appropriate vendors in accordance with approved quality and procurement procedures.

**h. Database Control**

Software used for data reduction, storage or evaluation will be fully documented and certified by the vendor. The software will be tested prior to use by an appropriate test data set.

**i. Data Management**

Survey data control from the time of collection through evaluation is specified by procedure. Manual data entries will be second verified.

**5.10.5 Assessment and Oversight**

**a. Assessments**

FSS self-assessments will be conducted in accordance with approved procedures. The findings will be tracked and trended in accordance with these procedures.

**b. Independent Review of Survey Results**

Randomly selected survey packages (approximately 5%) from survey units will be independently reviewed by the Quality Programs Department to ensure that the survey measurements have been taken and documented in accordance with approved procedures.

**c. Corrective Action Process**

The corrective action process, already established as part of the site's 10 CFR Part 50 Appendix B Quality Assurance Program, will be applied to FSS for the documentation, evaluation, and implementation of corrective actions. The process will be conducted in accordance with approved procedures which describe the methods used to initiate Condition Reports (CRs) and resolve self assessment and corrective action issues related to

FSS. The CR evaluation effort is commensurate with the classification of the CR and could include root cause determination, barrier screening and extent of condition reviews.

d. Reports to Management

Reports of audits and trend data will be reported to management in accordance with approved procedure.

5.10.6 Data Validation

Survey data will be reviewed prior to evaluation or analysis for completeness and for the presence of outliers. Comparisons to investigation levels will be made and measurements exceeding the investigation levels will be evaluated. Procedurally verified data will be subjected to the Sign test, the Wilcoxon Rank Sum (WRS) test, or WRS Unity test as appropriate. Technical evaluations or calculations used to support the development of DCGLs will be independently verified to ensure correctness of the method and the quality of data.

5.10.7 NRC and State Confirmatory Measurements

Maine Yankee anticipates that both the NRC and the State of Maine Department of Human Services (DHS) - Division of Health Engineering (DHE) may choose to conduct confirmatory measurements in accordance with applicable laws and regulations. The NRC may take confirmatory measurements to make a determination in accordance with 10 CFR 50.82(a)(11) that the final radiation survey and associated documentation demonstrate that the facility and site are suitable for release in accordance with the criteria for decommissioning in 10 CFR Part 20, subpart E. Maine state law requires Maine Yankee to permit monitoring by the Maine State Nuclear Safety Inspectors (22 MRSA 664, sub-§2, as amended by PL 1999, c. 739, §1 and 38 MRSA 1451, sub-§11, as amended by PL 1999, c. 741, §1) This monitoring includes, among other things, taking radiological measurements for the purpose of verifying compliance with applicable state laws (including the enhanced state radiological criteria) and confirming and verifying compliance with NRC standards for unrestricted license termination. Maine Yankee will demonstrate compliance with the 25 mrem/yr criteria of 10 CFR Part 20, Subpart E by demonstrating compliance with the enhanced state radiological criteria. Therefore, the confirmatory measurements taken by the NRC and the State of Maine will be based upon the same criteria, DCGL. Timely and frequent communications with these agencies will ensure that they are afforded sufficient opportunity for these confirmatory measurements prior to Maine Yankee implementing any irreversible decommissioning actions (e.g. backfilling basements with soil fill material.)

## 5.11 Access Control Measures

### 5.11.1 Turnover

Due to the large scope of the final status survey and the need for some activities to be performed in parallel with dismantlement activities, a systematic approach to turnover of areas is established. Prior to acceptance of a survey unit for final status survey, the following conditions must be satisfied, unless authorized by the FSS Superintendent in accordance with established procedures. These include:

- a. Decommissioning activities having the potential to contaminate the survey unit must be complete.
- b. Tools and equipment not required for the survey must be removed, and housekeeping and cleanup must be complete, except as noted in section 5.1.2.a.
- c. Decontamination activities in the area must be complete.
- d. Final remediation surveys, where applicable, must be complete. These surveys will consist of:
  1. Scan surveys or fixed measurements to ensure that surface contamination is within the FSS total surface contamination limits.
  2. Smear surveys to ensure that the removable surface contamination is within the FSS removable surface contamination limits (i.e., 10% of the surface contamination limit).
  3. Volumetric samples or scans to ensure soil remediation is within acceptable FSS concentration limits.
- e. Access control or other measures to prevent recontamination must be implemented.
- f. Turnover surveys may be performed and documented to the same standards as FSS surveys so that data can be used for FSS.

### 5.11.2 Walkdown

The principal objective of the walkdown is to assess the physical scope of the survey unit. For systems, it will include a review of system drawings and a physical

walkdown of the system. Structures and open land areas will also be walked down. The walkdown is best completed when the final configuration of the area is known, usually near or after completion of decommissioning activities for the area.

The walkdown ensures that the area has been left in the necessary configuration for FSS or that any further work has been identified. The walkdown provides detailed physical information for survey design. Details such as floor coatings, structural interferences or sources needing special survey techniques can be determined.

Specific requirements will be identified for accessing the survey area and obtaining support functions necessary to conduct the final status surveys, such as scaffolding, interference removal, and electrical tag out. Safety concerns, such as access to confined spaces, tidal areas, and high walls and/or ceilings, will be identified.

#### 5.11.3 Transfer of Control

Once a walkdown has been performed and the turnover requirements have been met, control of access to the area is transferred from the Construction and Radiation Protection operations groups to the FSS group. Turnover is accomplished using administrative controls. Access control and isolation methods are described below.

#### 5.11.4 Isolation and Control Measures

Since decommissioning activities will not be completed prior to the start of the final status survey, measures will be implemented to protect survey areas from contamination during and subsequent to the final status survey. Decommissioning activities creating a potential for the spread of contamination will be completed within each survey unit prior to the final status survey. Additionally, decommissioning activities which create a potential for the spread of contamination to adjacent areas will be evaluated and controlled.

Upon commencement of the final status survey for survey areas within the RA where there is a potential for re-contamination, implementation of one or more of the following control measures will be required:

- a. Personnel training
- b. Installation of barriers to control access to surveyed areas
- c. Installation of barriers to prevent the migration of contamination from adjacent overhead areas
- d. Installation of postings requiring contamination monitoring prior to surveyed area access

- e. Locking entrances to surveyed areas of the facility
- f. Installation of tamper-evident labels

Routine contamination surveys will be performed in areas following FSS completion to monitor for indications of re-contamination and to verify postings and access control measures. Survey frequency will be based on the potential for re-contamination as determined by the FSS Superintendent. At a minimum, routine surveys will be performed quarterly for structures located within the RA. Routine contamination control surveys will not be required for open land areas and structures outside of the RA that are not normally occupied and are unlikely to be impacted by decommissioning activities.

Routine surveys of areas where FSS has been completed will normally include survey locations at floor level and on lower walls. Locations will be selected on a judgmental basis, based on technician experience and conditions present in the survey area at the time of the survey, but are primarily designed to detect the migration of contamination from decommissioning activities taking place in adjacent and other areas in close proximity which could cause a potential change in conditions.

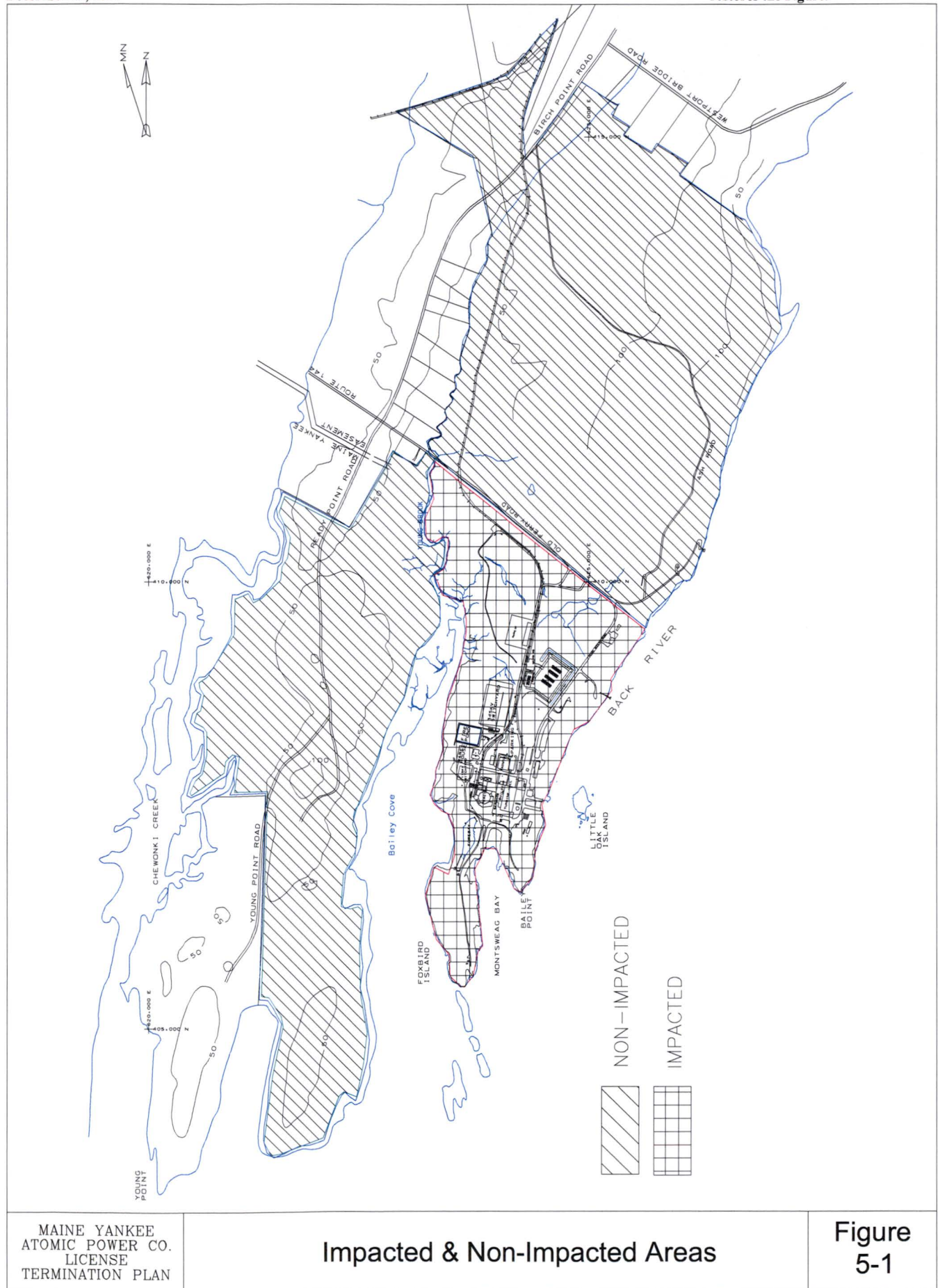
#### 5.12 References

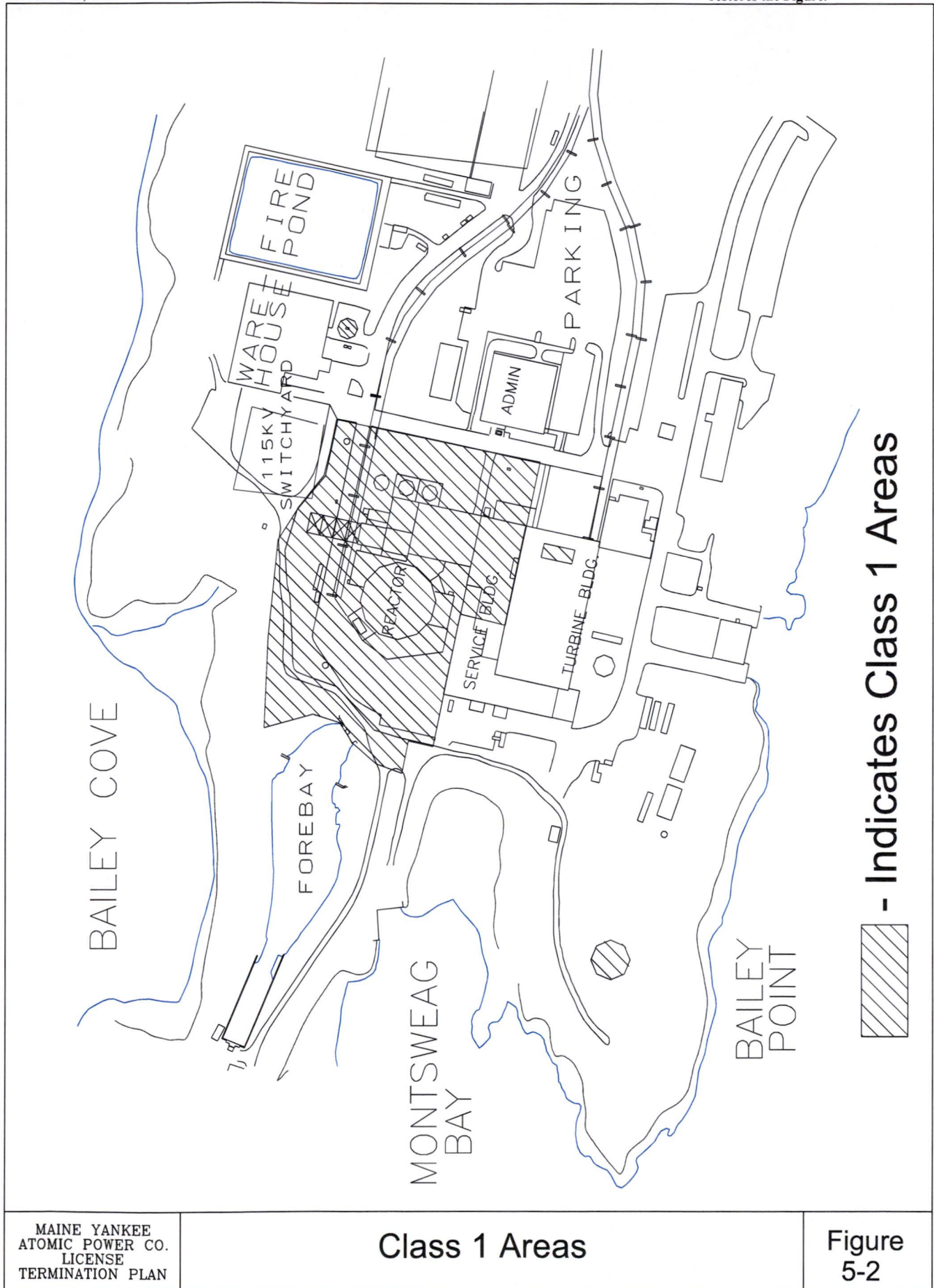
- 5.12.1 10CFR20.1402, Radiological Criteria for Unrestricted Use.
- 5.12.2 10CFR50.82, Termination of License.
- 5.12.3 40CFR141.25 through 27, National Primary Drinking Water Regulations.
- 5.12.4 State of Maine Law - LD 2688-SP1084, "An Act to Establish Clean-up Standards for Decommissioning Nuclear Facilities," April 26, 2000
- 5.12.5 MY Post Shutdown Decommissioning Activities Report (PSDAR), MN-97-99, dated August 27, 1997 as supplemented by MN-98-65 dated November 3, 1998 .
- 5.12.6 MY Historical Site Assessment, as transmitted by MN-01-038 dated October 1, 2001.
- 5.12.7 GTS Duratek, "Characterization Survey Report for the Maine Yankee Atomic Power Plant," Volumes 1-9, 1998.

- 5.12.8 MY Quality Assurance Program.
- 5.12.9 MY Corrective Action Program.
- 5.12.10 NUREG-1575, "Multi-Agency Radiation Survey and Site Investigation Manual" (MARSSIM), Revision 1 (June 2001)
- 5.12.11 NUREG-1507, "Minimum Detectable Concentrations With Typical Radiation Survey Instruments for Various Field Conditions," December 1997
- 5.12.12 NUREG-1505, "A Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys," Rev.1, June 1998 draft.
- 5.12.13 NUREG-1549, "Using Decision Methods for Dose Assessment to Comply with Radiological Criteria for License Termination," July 1998 draft.
- 5.12.14 Appendix E, NUREG 1727, "Demonstrating Compliance with the Radiological Criteria for License Termination," September 15, 2000.
- 5.12.15 NUREG-1727, "NMSS Decommissioning Standard Review Plan," September 15, 2000.
- 5.12.16 Initial and Continuing Training For Decommissioning course descriptions.
- 5.12.17 Radiation Protection Performance Assessment Program (PMP 6.0.8).
- 5.12.18 Radiation Protection Instrumentation Program (PMP 6.4).
- 5.12.19 Operation and Calibration of the Gamma Spectroscopy System (DI 6-306).
- 5.12.20 Operation of the Packard Model 4430 Liquid Scintillation (DI 6-316)
- 5.12.21 Final Status Survey Program (PMP 6.7).
- 5.12.22 FSS Survey Procedure for Structures, Systems and Soils (PMP 6.7.1).
- 5.12.23 FSS Survey Unit Classification (PMP 6.7.2).
- 5.12.24 FSS Quality Control (PMP 6.7.3).

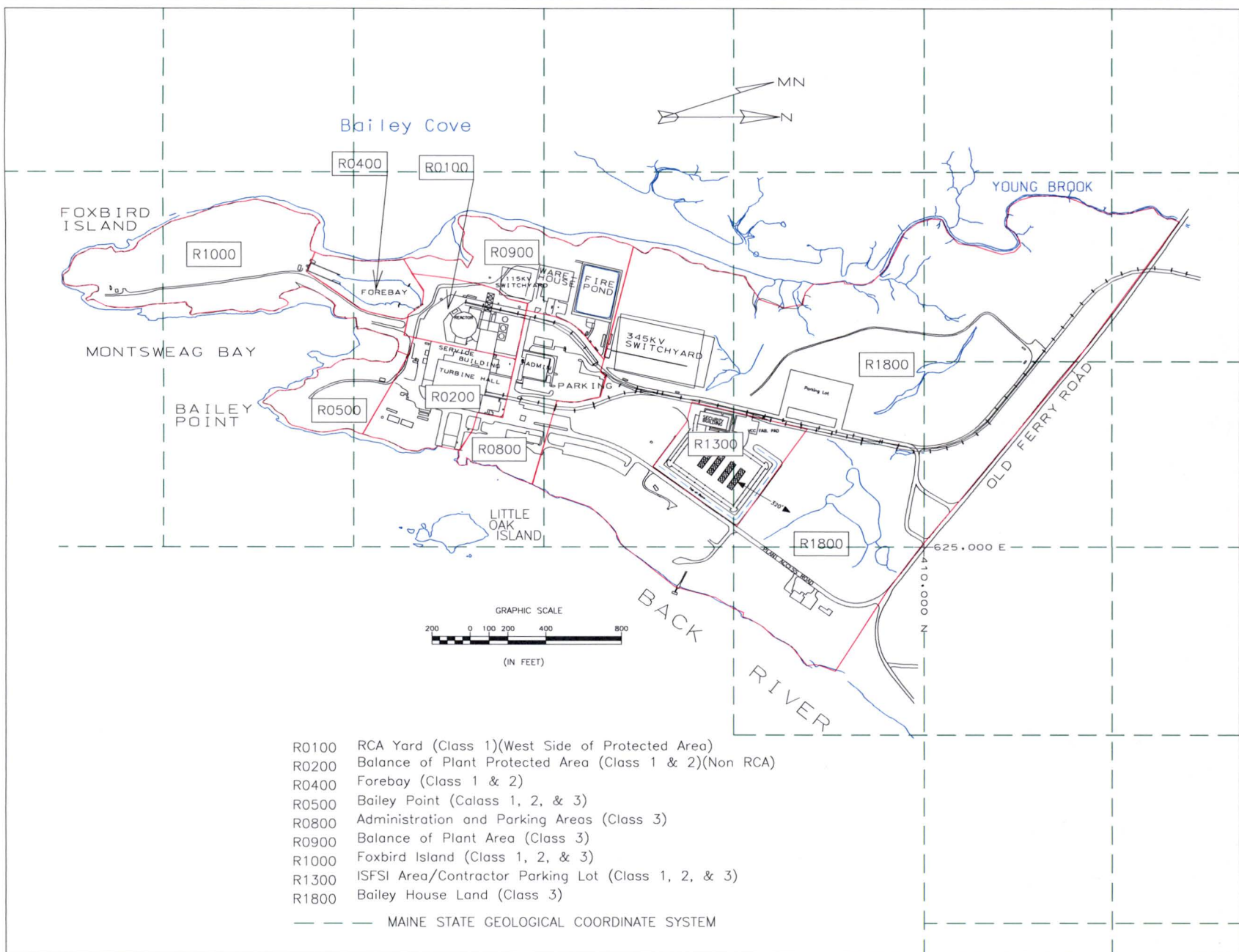


- 5.12.25 FSS Survey Package Preparation and Control (PMP 6.7.4).
- 5.12.26 FSS Survey Area Turnover and Control (PMP 6.7.5).
- 5.12.27 FSS Data Processing and Reporting (PMP 6.7.8).
- 5.12.28 Selection, Training and Qualification of RP/Waste Personnel (PMP 6.9).
- 5.12.29 Instrument Quality Assurance (PMP 6.4.1).
- 5.12.30 Document Control Program (0-17-1).
- 5.12.31 Operation of the Tennelec LB-5100 Gas Flow Proportional Instrument procedure (DI 6-210).
- 5.12.32 Instrument Selection and MDC Calculation (EC 009-01).
- 5.12.33 NRC letter to Maine Yankee, dated August 23, 2002 regarding classification downgrade and other LTP issues.
- 5.12.34 Use of the SPA-3 Detector for Concrete Scan Surveys (EC 002-03)
- 5.12.35 White Paper 2002-001, "The Approach for Dealing with Background Radioactivity for Maine Yankee Final Status Surveys"
- 5.12.36 Revised Report on Eberline Model E-600 Field Testing (MN- 03-009)
- 5.12.37 Maine Yankee Letter to NRC, MN-03-051, dated September 3, 2003, Technical Basis Document for NRC Review - Forebay FSS Survey Measurement Methods (In-Situ Gamma Spectroscopy) - 30 Day Notice per LTP Requirement
- 5.12.38 Maine Yankee Letter to NRC, MN-03-067, dated October 21, 2003, Maine Yankee Response to NRC and State of Maine Comments on the Technical Basis Document for NRC Review - Forebay FSS Survey Measurement Methods (In-Situ Gamma Spectroscopy)





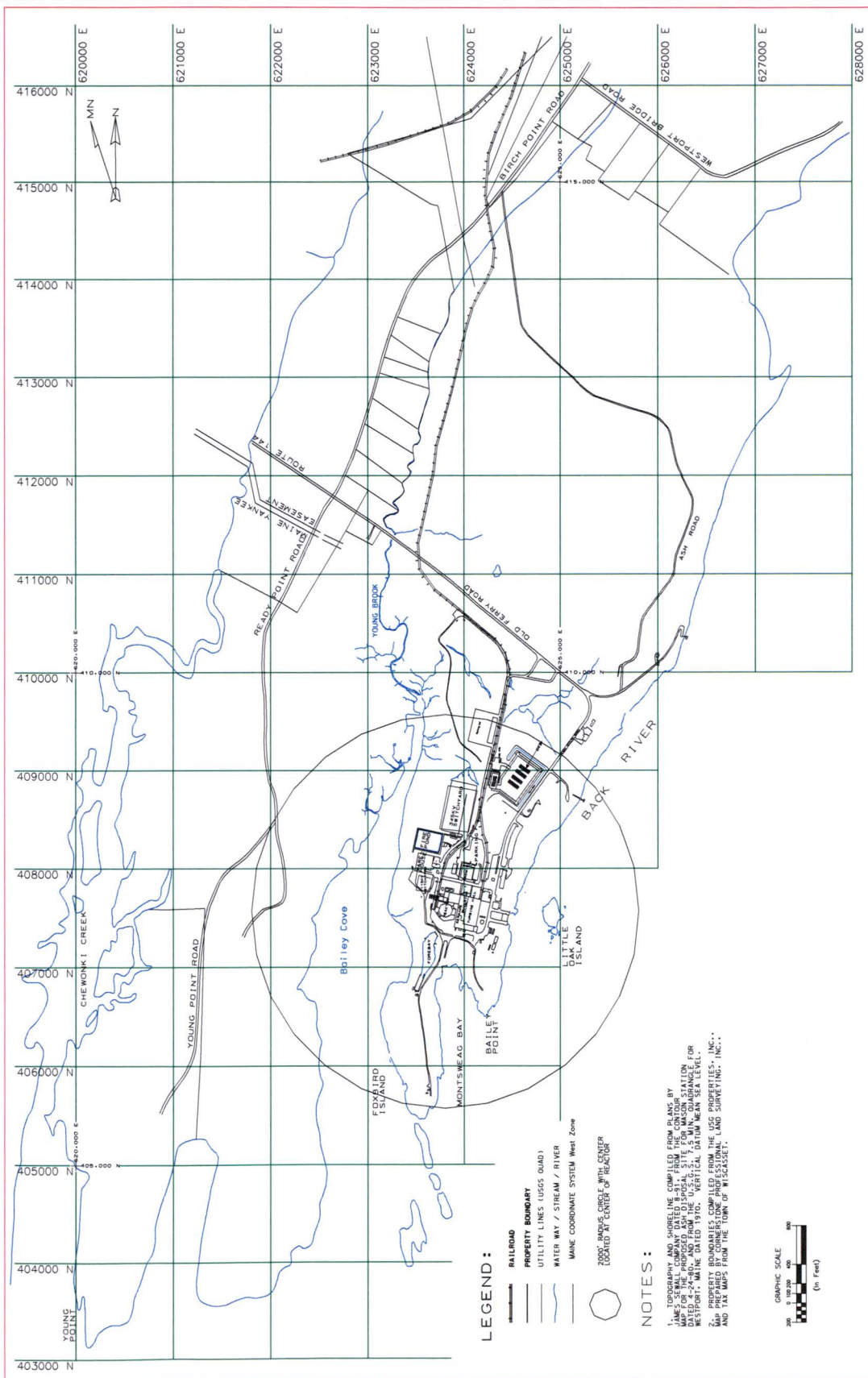


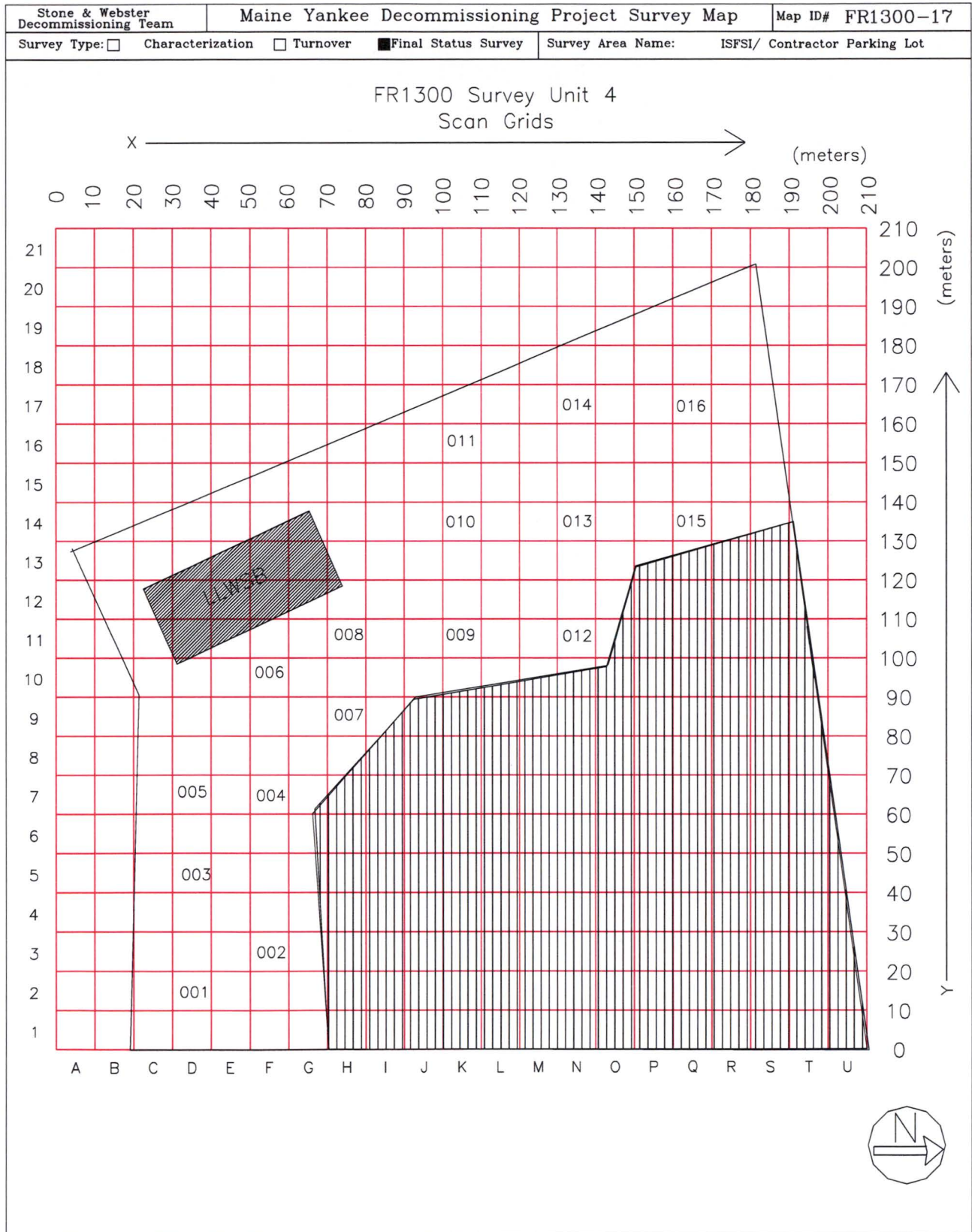


MAINE YANKEE  
 ATOMIC POWER CO.  
 LICENSE  
 TERMINATION PLAN

Survey Areas

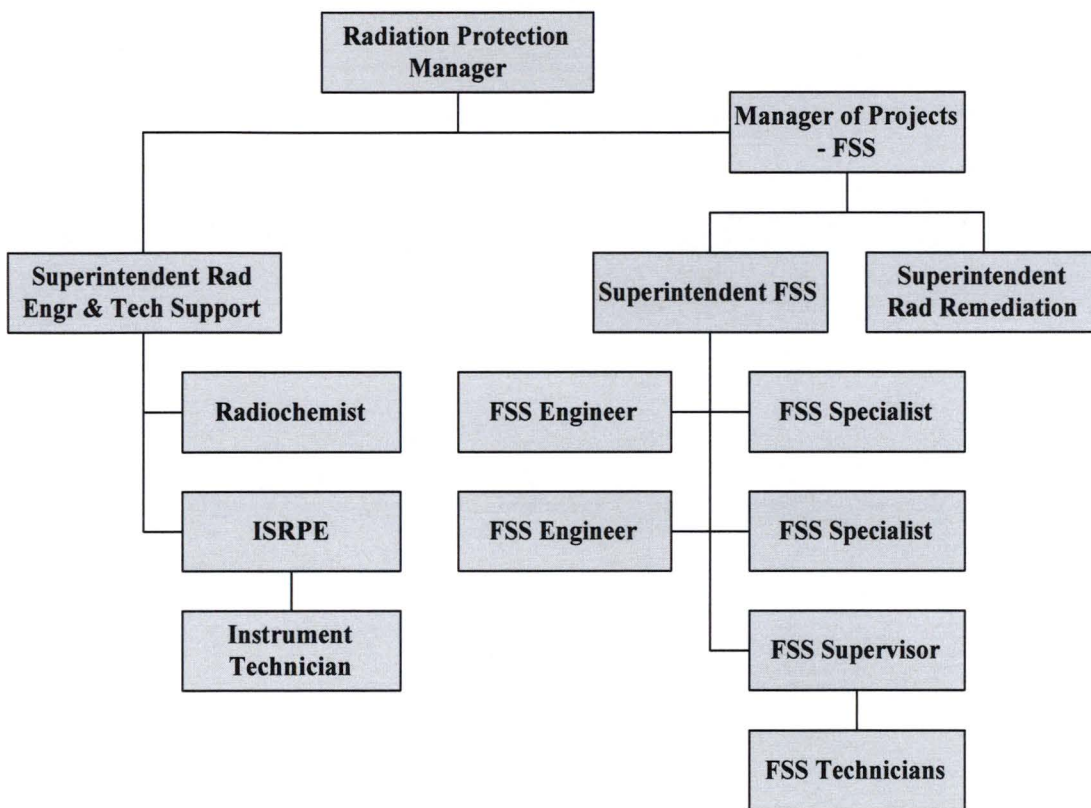
Figure  
 5-3







**Figure 5-6**  
**FSS Project Organization<sup>1</sup>**



<sup>1</sup> See Section 5.10.1 for discussion of the relationship between the FSS project organization and the Maine Yankee Quality Assurance Program.

**ATTACHMENT 5A**

**Embedded and Buried Pipe**  
**Initial Final Survey Classification Description**



### **Embedded and Buried Piping Remaining on Site:**

The following sections of embedded and buried piping will remain on site following demolition of above grade structures. This list includes a description of the piping, the potential for the piping to contain residual contamination and a description and the initial MARSSIM classification of the survey units.

On September 30, 2005, NRC issued Amendment No. 172 consisting of the unrestricted release of the remaining land under License No. DPR-36 with the exception of the land where the ISFSI is located and a parcel of land adjacent to the ISFSI. These areas are not anticipated to have any embedded or buried piping. The following information is retained for historical purposes.

#### **Containment Spray (C0300)**

**System Description:** The function of the Containment Spray (CS) system was to reduce the peak pressure in the containment building following a loss of coolant accident by spraying water into the containment atmosphere, to remove radioactive iodine, which would be released to the containment atmosphere during a loss of coolant accident, and to supply water to the suction of the High Pressure Safety Injection pumps following receipt of a Recirculation Actuation Signal (RAS) to provide the required suction head. The CS system initially took suction from the Refueling Water Storage Tank. The system could take an alternate suction from the containment safeguards sump upon receiving the RAS signal.

**Residual Contamination Potential:** The Containment Spray piping has a high potential for residual contamination. The portion of the piping that will remain following demolition of above grade structures is embedded in the concrete foundation of the Containment Building. The water source available for the system, Refueling Water Storage Tank, was contaminated.

**Survey Units:** The Containment Spray piping will be surveyed as a single survey unit. The survey unit will have an initial MARSSIM classification of Class 1. The classification is based on the known presence of contamination in the suction source for the system.

#### **Containment Foundation Drains (C2000)**

**System Description:** The Containment Foundation Drain piping is used to transfer groundwater from around the foundation of the Containment Building to lower the hydrostatic pressure exerted on the foundation. The remaining piping consists of four, two inch ID, horizontal, plastic, transfer pipes at approximately the -46' 6" elevation which run radially from underneath the ICI pit to the Containment Foundation Drain Sump Pumpwell and one, six inch, horizontal, open joint clay pipe at approximately the -18' 6" elevation which runs about 90 degrees around the southwest circumference of the containment foundation from the Spray Building to the Containment Foundation Drain Sump Pumpwell. The horizontal transfer pipes drain to the common, vertical, six foot ID, Containment Foundation Drain Sump Pumpwell which runs from the -52' 3" elevation to grade level.

**Residual Contamination Potential:** The Containment Foundation Drain piping has a potential for residual contamination, but is not likely to contain residual radioactivity in excess of the DCGL<sub>w</sub>. The piping is wholly contained in the Restricted Area and there are known instances of contaminated liquid spills in

the area around the Containment Building.

**Survey Units:** The Containment Foundation Drain piping will be surveyed as a single survey unit. The initial MARSSIM classification of the survey unit was Class 1. The basis for classification was operational knowledge of the system and data collected in support of the Radiological Environmental Monitoring Program. Upon reevaluation of continued characterization data with respect to the balance of plant embedded piping DCGLw, this survey unit has been reclassified to Class 2.

#### Sanitary Waste (D0400)

**System Description:** The Sanitary Waste (SW) piping was used to transfer waste from the various buildings on site to the Sewage Treatment Plant where the waste was treated prior to disposal. The system transferred waste from all areas of the site including sanitary facilities formerly located in the Restricted Area. The portions of the piping that will remain after the demolition of above grade structures will be contained within the Manhole system described in the Storm Drains system. The Radiological Environmental Monitoring Program requires that this outfall be monitored periodically. The original outfall for the system was to the Back River following treatment. In the mid-1980s, the outfall for the system was connected to the city of Wiscasset sewage treatment system.

**Residual Contamination Potential:** The Sanitary Waste piping has a low potential for residual contamination. The leg of the piping that formerly serviced the sanitary facilities in the Restricted Area was removed from service in the early 1980s. Other portions of the system may have been contaminated with medical isotopes; however, these isotopes are short lived and should be decayed away by the time the system is surveyed.

**Survey Units:** The abandoned leg of the Sanitary Sewer piping that connected the sanitary facilities in the Restricted Area to the Sewage Treatment Plant will be surveyed as a single survey unit. The initial MARSSIM classification of the piping will be Class 3. The classification is based on operational knowledge of the system and survey data collected during initial site characterization<sup>1</sup>.

#### Circulating Water (D0500)

**System Description:** The Circulating Water (CW) system supplied cooling water to the main condenser tube bundles. The system took suction from the Back River at the Circulating Water Pump House. Four CW pumps took suction from an individual bay and discharged to an individual tube bundle. The CW in the tube bundle removed heat from the turbine exhaust steam that condensed the steam to condensate water for return to the steam generators. The CW exiting the tube bundles combined and was directed to the seal pit and the forebay. Water from the seal pit and forebay was returned to the Back River. The Circulating Water system is considered a "secondary side" system in that there was a physical barrier

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<sup>1</sup> "Initial site characterization" (or ICS) refers to the initial characterization work performed by GTS Duratek as documented in the "Characterization Survey Report for the Maine Yankee Atomic Power Plant," 1998. (See the Reference Section 5.12.) "Continuing characterization" refers to additional characterization which followed the ICS and is an ongoing activity which collects additional data, as required, to support remediation, dose assessment, and FSS activities. See also Section 2.1.

(Main Steam and Condensate systems) between the water in the Circulating System and the contaminated systems of the primary plant (Reactor Coolant, etc.).

**Residual Contamination Potential:** The Circulating Water piping has a very low potential for residual contamination. The piping was separated from the primary system by several interface systems. The Steam Generator U-tubes acted as the separator for the primary and secondary systems, and the main condenser tube bundles acted as the separator for the secondary system (Main Steam, Condensate, etc.) and the CW piping. The operational history of the facility indicates that no significant primary to secondary leakage occurred, implying that there is a very remote chance the system may have become contaminated. Additionally, CW system pressure was maintained above the pressure of the turbine exhaust steam. In the event of a tube bundle leak, the CW system water would have leaked into the Condensate system instead of Condensate leaking into the CW system. During site characterization activities, low levels of detectable activity were identified on the main condenser outlet side of the Circulating Water piping. Continuing Characterization Survey samples collected in the CW piping identify very low levels of plant related radionuclides. The suspected cause of the contamination was recirculation of allowable effluent discharges into the suction side of the Circulating Water Pump House.

**Survey Units:** The Circulating Water system will be divided into two survey units. The first survey unit will consist of the inlet side piping ending at the floor of the Turbine Hall where the pipes have been cut off at floor level. The second survey unit will consist of the outlet side piping at the floor of the Turbine Hall where the pipes were cut off at floor level and ending at the Seal Pit and Fore Bay area. Both survey units for this survey area will initially be classified as MARSSIM Class 3. The basis for classification of the survey units is operational knowledge of the system, data obtained in support of the Radiological Environmental Monitoring Program, and limited sampling of the piping conducted during site characterization surveys.

#### Service Water (D0600)

The Service Water System consists of two buried inlet pipes that carried sea water through the component cooling heat exchangers. The discharge of the system consists of a single buried line that goes into the seal pit.

The discharge side of the pipe receives the liquid effluent discharge pipe. The waste header is contained within its own local Restricted Area within the Turbine Building. During Site Characterization, low levels of detectable activity were identified on the discharge side of the piping. No direct beta measurements were above the MDA. Nine samples of removable beta activity were detected above the MDA (3134 dpm/100cm<sup>2</sup> was the maximum value). The positive indications of residual activity in this system are associated with the liquid effluent header location and the liquid radwaste radiation monitor installed at that location. Gamma isotopic samples collected at the liquid effluent line entrance point and at the radiation monitor were positive for Co-60 (700 pCi/g).

The radwaste piping will be removed and disposed of as radioactive waste. The buried inlet portions of the Service Water system will be removed outside of the Turbine Building and the portions beneath the Turbine Building will be abandoned in place. The remaining portions of the service water discharge piping meet the criteria of a Class 3 area and will be surveyed as a single survey unit.

### Fire Protection (D0700)

**System Description:** The water portion of the Fire Protection (FP) system is the only section that will remain following demolition of above grade structures. Water for firefighting was stored in a man-made storage pond located northwest of the plant. Makeup water for the pond was supplied from the Montsweag Reservoir. Water was transferred to the storage pond by two reservoir pumps, which were operated as required to keep the storage pond full. The former storage pond is addressed as part of survey area R0900. Two fire pumps took suction from the storage pond and discharged to the yard loop where they supplied various fire headers and hydrants. The FP system did not supply firefighting water to the Containment Building. The hose stations in the Containment Building were supplied from the Primary Water System. The Fire Protection system is considered a "support system" in that it did not interface with the primary or secondary side of the nuclear steam supply system.

**Residual Contamination Potential:** The Fire Protection piping has a very low potential for residual contamination. The piping did not interface with either the primary or the secondary side systems of the nuclear steam supply system. Although sections of the piping reside in the Restricted Area, the system operating pressure, even at static head conditions, was sufficient to ensure that any leakage would occur from the system, not into the system. The Fire Water Protection system has been inadvertently cross connected with potentially contaminated systems in the past. Samples collected during the Continuing Characterization Survey have only identified naturally occurring radioactive material. No licensed activity has been identified in the system.

**Survey Units:** The Fire Protection piping will be surveyed as a single survey unit. The survey unit will consist of all buried and embedded piping remaining after the demolition of the site above grade structures. The initial MARSSIM classification for the Fire Protection piping will be Class 3. The classification is based on knowledge of system operation and samples collected in the storage pond during site characterization surveys and samples of the system collected as part of the Continuing Characterization Survey.

### Storm Drains (D3500)

**System Description:** The Storm Drain (SD) system is used to drain water from the facility to the Back River. The system functions as a gravity drain system to remove the water via a system of drain grates, manholes and piping. The system drains the entire site both inside and outside the Protected Area. Manholes 1 through 3 (Section 1 of the piping) drain the Protected Area outside the Restricted Area and south of the Turbine Building and Service Building. The outfall for this portion of the piping is a 24" line that drains to the Back River south of the Circulating Water Pump House (CWPH). Manholes 4 and 5 (Section 2 of the piping) drain an area inside the Protected Area outside the Restricted Area east of the Turbine Building. This line drains the area around the Main Transformers. The outfall for this leg of the piping is a 15" line that drains to the Back River north of the CWPH. Manholes 6 through 11 and un-numbered manholes north of the Turbine Building (Section 3 of the piping) drain an area both inside and outside the Protected Area. The area drained is all outside the Restricted Area. These legs all collect at Manhole 7 and the combined outfall is routed to the Back River immediately adjacent to the north side of the CWPH. Manholes 13 and 14 (Section 4 of the piping) drain the upper access road and the upper contractor parking lot. The outfall for this section of the piping is the Back River north of the Information Center building. Manholes 30A, and 31 through 37 (Section 5 of the piping) drain an area

inside the Protected Area in the Restricted Area. This leg of the piping drains the main RCA Yard area around the Containment Building and the alley between the Containment Building and the Service Building. These legs all collect at Manhole 35 and the combined outfall is routed to the Seal Pit Forebay. Manholes 21 through 24 (Section 6 of the piping) drain the north side of the Restricted Area and the roof of the WART Building. The area drained is inside the Protected Area and both inside and outside the Restricted Area. The combined outfall for this leg joins another leg at Manhole 27. Manholes 25A, 25B, 26 through 29 and 38 (Section 7 of the piping) drains areas adjoining the Fire Pond and Warehouse and outside the west end of the Restricted Area. The outfall from Manhole 24 joins this leg at Manhole 27. The combined outfall for this leg of the piping is routed to Bailey Cove.

**Residual Contamination Potential:** The Storm Drain piping has a low potential in some legs and a high potential in some legs for residual contamination. Sections 1 through 4 and section 7 upstream of manhole 27 have a low potential for residual contamination. Sections 5 through 7 (downstream of and including manhole 27) have a high potential for residual contamination. Sections 1 through 4 and section 7 upstream of manhole 27 drain areas that have historically been outside the Restricted Area and have a low potential for residual contamination. Sections 5 through 7 (downstream of and including manhole 27) drain areas in and adjacent to the Restricted Area and may have become contaminated due to loose surface contamination in and on yard structures and equipment being washed into the drain legs by rain water runoff and snow melting.

**Survey Units:** The Storm Drain piping may be divided into two survey units. The first survey unit will include sections 1 through 4 and section 7 upstream of manhole 27 of the piping. The initial MARSSIM classification for this section of the piping will be Class 3. The basis for classification is operational knowledge, survey data obtained for initial site characterization activities and as part of the Continuing Characterization Survey, and results of the Radiological Environmental Monitoring Program. The second survey unit will consist of sections 5 through 7 (downstream of and including manhole 27) of the piping. The initial MARSSIM classification for this section of the piping will be Class 1. The basis for classification is operational knowledge and survey data obtained during initial site characterization and the Continuing Characterization Survey.

### Roof Drains (D3600)

**System Description:** The Roof Drain (RD) system removed water from the roofs of various site buildings and transferred the water to the Storm Drain system. The Roof Drains from buildings outside the RCA were routed to the Storm Drain piping sections that will be classified as Class 3. The Roof Drains from buildings inside the RCA were routed to the Storm Drain piping sections that will be classified as Class 1.

**Residual Contamination Potential:** Sections of the Roof Drain system outside the RCA have a low potential for residual contamination. Sections of the Roof Drain system inside the RCA have a high potential for residual contamination.

**Survey Units:** The portions of the system that will remain following demolition of above grade structures are buried and embedded sections of the system that are associated with the Storm Drain system. For this reason, the Roof Drains will be surveyed as part of the Storm Drain system.

Containment, Primary Auxiliary Building and Containment Spray Building Penetrations (D3700)

System Description: Several Containment Building penetrations will remain following demolition of the above grade structure. The penetrations contain embedded piping from numerous primary and secondary systems. The remaining penetrations are as follows:

- Approximately 20 linear feet of up to 1" piping
- Approximately 35 linear feet of 1.5" piping
- Approximately 50 linear feet of 2" piping
- Approximately 35 linear feet of 3" piping
- Approximately 55 linear feet of 4" piping
- Approximately 100 linear feet of 6" piping
- Approximately 45 linear feet of 8" piping
- Approximately 5 linear feet of 10" piping
- Approximately 25 linear feet of 16" piping
- Approximately 10 linear feet of 24" piping
- Approximately 20 linear feet of 30" piping
- Approximately 11 linear feet of 40" Fuel Transfer Tube piping

Each of these penetration, except for the Fuel Transfer Tube, consists of a five foot length of pipe penetration through the containment foundation wall. The calculated surface area of this embedded piping is approximately 78 m<sup>2</sup>.

The Primary Auxiliary Building and Spray Building Penetrations (60ft). Several non-containment piping penetrations through the Primary Auxiliary Building and Spray Building will remain in the respective building foundations following demolition of the above grade structure. Each of these penetrations consists of a 2 to 3 foot length of pipe penetration through the building foundation wall. The calculated surface area of this embedded piping is approximately 19.5 m<sup>2</sup>.

The spent fuel pool liner leak detection system (24ft). Four 1 inch lines embedded in the spent fuel pool structure will remain following demolition of the above grade structure. The calculated surface area of this embedded piping is approximately 0.6 m<sup>2</sup>.

Residual Contamination Potential: The penetrations that will remain in the Containment Building, Primary Auxiliary Building and Spray Building have a high potential for residual contamination. One of the systems identified as having a remaining section of embedded piping is Containment Spray, which is known to contain residual contamination.

Survey Units: The remaining sections of embedded piping in the Containment Building may be surveyed as a single survey unit. The initial MARSSIM classification assigned to the penetrations is Class 1. The basis for classification is the known presence of contamination in the Containment Spray system, the potential for residual contamination in the remaining piping due to system operation and lack of control of the penetrations to prevent contamination during dismantlement activities in the Containment Building.

## **Class 1 Survey Units:**

### **Containment Spray System (C0300)**

**Physical Characteristics:** The remaining embedded section of the Containment Spray piping consists of metal piping.

**Decontamination:** Prior to performing the FSS, the remaining piping will be decontaminated. The decontamination will consist of hydrolasing the embedded piping from the Containment Safeguards Sump to the suction of the Containment Spray Pumps. Following the hydrolasing, the leg of embedded piping will be surveyed for gross removable contamination.

**Scan surveys** for the Containment Spray piping will be conducted at the accessible ends of the embedded piping. The surface area scanned will be a small percentage of the total area of the system. The location of the measurements will be determined by dividing the total length of the pipe by the number of measurements to be collected. The systematic spacing of the survey measurements is in keeping with the guidance of NUREG-1575 and NUREG-1727. Total Surface Contamination measurements will be collected using a pipe crawler.

### **Containment Foundation Drains (C2000) - Moved to Class 2 Survey Units**

### **Storm Drains (D3500)**

**Survey Unit:** The Class 1 survey unit for the Storm Drain piping consists of the section of the piping bound by Manholes 30A and 31 through 37 and the section of the piping bound by Manholes 21 through 24. The survey unit includes an unnumbered manhole adjacent to the location of tank TK-16 in the Restricted Area yard.

**Physical Characteristics:** The remaining sections of buried Storm Drains piping consist of both metal and concrete piping. Some of the metal sections are smooth wall and some are corrugated.

**Decontamination:** The piping will require decontamination prior to performance of the Final Status Survey. The decontamination will consist of removing the sand and sediment from the piping low points and accesses (the manholes). The sand in the piping contains naturally occurring radioactive material.

**Scan Surveys:** Although this is Class 1 piping, physical access limits available measurement locations and scan survey locations. Therefore, scan surveys for the Storm Drain piping will be limited to accessible portions of the piping. Scan surveys will be performed in areas with the highest potential for contamination based on professional judgment. For this reason, the scan survey will be biased to piping low points and interfaces and the scan survey will be performed in the vicinity of the Total Surface Contamination measurements identified for the piping. Scan surveys will be performed on as much of the interior surfaces of the piping as possible.

**Survey Location Designation:** Survey measurements for the Storm Drain piping will be collected at existing access points. The locations will be selected based on engineering judgment and biased to areas expected

to contain the highest residual activity levels. As the Final Status Survey of the remaining embedded and buried piping for the Storm Drain system will be biased and not random, the minimum number of measurements collected on the system interior surfaces will be the number calculated using the methods described above or 30 measurements, whichever is greater.

#### Building Penetrations (D3800)

**Physical Characteristics:** The remaining embedded piping in the Building Penetrations survey unit consists of smooth metal piping surfaces.

**Decontamination:** The embedded piping remaining in the system will be decontaminated prior to performance of the Final Status Survey.

**Scan Survey Coverage:** 100% of the accessible system surfaces will receive a scan survey. Sections of embedded piping that are inaccessible will receive 100% gross removable contamination surveys. This will include sections that are too small to allow probe entry into the pipe.

**Survey Location Designation:** Each penetration will be assigned a number. The number of fixed point measurements will be calculated using the method described in the "sample size determination" section of this plan. The measurements will be randomly assigned to the penetrations. The random measurements will be used due to the difficulty of performing a systematic survey of the penetrations. The penetrations reside at multiple elevations of the building in a non-contiguous manner. These factors make it virtually impossible to perform a systematic survey of the penetrations.

#### **Class 2 Survey Units:**

##### Containment Foundation Drains (C2000)

**Physical Characteristics:** The remaining buried sections of the Containment Foundation Drains piping consists of plastic and clay piping. The vertical pumpwell wall has perforated sections to allow groundwater to enter the pumpwell. The horizontal piping consists of intact plastic and open joint clay piping.

**Decontamination:** The Containment Foundation Drain piping is not expected to require decontamination. Samples of the outlet of the piping collected for the Radiological Environmental Monitoring Program have identified Tritium as the only plant related radionuclide in the outlet.

**Scan Surveys:** Scan surveys for the Containment Foundation Drain piping will be limited to accessible portions of the piping from the Containment Foundation Drain Sump Pumpwell. Scan surveys will be performed on 10 to 100% of the interior surfaces of the piping and pumpwell. The number of measurements will be determined using the sign test and will be applied to the total accessible surface area of the pipe and pumpwell. The systematic spacing of the survey measurements is in keeping with the guidance of NUREG-1575 and NUREG-1727. Total Surface Contamination measurements will be collected using a manually deployed detector. When direct sample locations fall upon surfaces which are not amenable to surface detection (e.g., moisture saturated surfaces or pipe access restricted by calcium build-up), the volumetric samples of concrete or internal pipe scrapings will be taken and analyzed in accordance with Section 5.5.1.a.



A volumetric sample will also be taken of sediment accumulated at the bottom of the sump pumpwell, if available.

### **Class 3 Survey Units:**

#### **Scan Survey Coverage:**

Scan surveys for Class 3 system survey units will be determined based on the Historical Site Assessment (HSA) for the survey unit. In cases where the initial site characterization and the continuing site characterization did not identify the presence of removable contamination or fixed point total surface contamination in excess of the DCGL<sub>w</sub>, the areal extent of the scanning will be determined by engineering judgment and should be in the range of 1 to 10% of the accessible surfaces of the system. Section 5.5.3 of NUREG-1575 recommends that scan surveys be performed in areas with the highest potential for contamination based on professional judgment. For this reason, the scan survey will be biased to system low points and system interfaces and the scan survey will be performed in the vicinity of the Total Surface Contamination measurements identified for the system.

#### **Sample Size Determination:**

The number of samples required for a survey unit is based on the following:

Statistical Test to be used: For Class 3 system survey units, the sign test will be used to test the null hypothesis.

Estimate of Standard Deviation: The estimated standard deviation values for the systems will be derived from characterization data or measurements additional background measurements, if necessary. In the event that there is insufficient data to estimate the standard deviation, the standard deviations developed for Class 3 structural survey units with similar contamination potential as the system (i.e. Turbine Building 21' elevation may be used for the Circulating Water system). The basis for the estimated standard deviation used for the design of the Final Status Survey of the survey area or survey unit will be given in the survey package design instructions.

The previously listed factors directly impact the number of measurements that will be collected in each survey unit. This method of calculating the number of survey measurements is valid regardless of the size of the survey unit or the type of material (i.e. structure or open land area) being surveyed. Experience has shown that this method typically requires that approximately 14 measurements are required for each survey unit at the Maine Yankee site. This method may also be used to determine the number of measurements required to demonstrate compliance in a system survey unit. The basis for the method described is that random designation of survey measurement location allows for a lower sample population to be used for the statistical analysis of the survey unit. As the Final Status Survey of the remaining embedded and buried piping systems will be biased and not random, the minimum number of measurements collected on the system interior surfaces will be the number calculated using the methods described in the "Sample Size Determination" section or 30 measurements, whichever is greater.

**MAINE YANKEE**

**LTP SECTION 6**

**COMPLIANCE WITH RADIOLOGICAL DOSE CRITERIA**

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Fill Direct Dose Microshield Output

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BNL Kd Report for Fill

**Attachment 6-3**

BNL Kd Report for Concrete

**Attachment 6-4**

Irrigation Memorandum

**Attachment 6-5**

Concrete Density

**Attachment 6-6**

Deleted

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Remaining Embedded Piping

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Deep Soil Microshield Output

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## 6.0 COMPLIANCE WITH THE RADIOLOGICAL DOSE CRITERIA

### 6.1 Introduction

The goal of the MY decommissioning project is to release the site for unrestricted use in compliance with the NRC's annual dose limit of 25 mrem/y plus ALARA and the enhanced State of Maine clean-up criteria of 10 mrem/y or less for all pathways and 4 mrem/y or less for groundwater sources. Both the State and NRC dose limits apply to residual radioactivity that is distinguishable from background. This section provides the methods for calculating the annual dose from residual radioactivity that may remain when the site is released for unrestricted use.

The dose assessment methods are used to determine Derived Concentration Guideline Levels (DCGLs) for nine different potentially contaminated materials. The DCGLs are the levels of residual radioactivity that correspond to the enhanced state clean-up criteria of 10 mrem/y or less for all pathways and 4 mrem/y or less for groundwater sources to the average member of the critical group. The DCGLs developed to demonstrate compliance with the enhanced State criteria are intended to also serve to demonstrate compliance with the NRC's 25 mrem/y plus ALARA regulation.

Maine Yankee intends to dismantle equipment and systems and remediate structures and land areas (per LTP Sections 3 and 4) to ensure that residual radioactivity levels are at, or below, the DCGLs. After remediation is completed, a final site survey will be performed (per LTP Section 5) to verify compliance with the DCGLs. The final survey report will document that the DCGLs have been met and serve to demonstrate that the Radiological Criteria for License Termination, as codified in 10 CFR 20 Subpart E and Maine State Law LD 2688-SP 1084 have been fully satisfied.

A dose assessment will be performed for each of the following materials: 1) contaminated building basement surfaces; 2) embedded pipe; 3) activated concrete/rebar; 4) groundwater; 5) surface water; 6) surface soils; 7) buried piping; 8) deep soils; and 9) Forebay sediment. Appropriate dose models and model input parameters were developed and justified for each material. The dose from each material was evaluated and summed with that from other materials as necessary to determine the total dose to the average member of the critical group.

As of September 30, 2005, the only decommissioning activities that remain are those associated with the ISFSI. The information included in this section of the LTP includes historical information regarding the decommissioning of the Maine Yankee Nuclear Plant that will be maintained in its current form. This information will be reviewed, and revised as necessary, at the time of initiating the decommissioning activities for the ISFSI and associated land areas to ensure that appropriate information is available for the



implementation of final status survey activities for the ISFSI and termination of the Part 50 License for the Maine Yankee site.

## 6.2 Site Condition After Decommissioning

This section provides a brief overview of the planned site condition after decommissioning as well as a summary of site geology and hydrology. Detailed information on the planned final site condition is provided in Section 3.2.4. LTP Section 8.4 provides a more detailed overview of the geological and hydrological characteristics of the site.

In general, when decommissioning is complete the site will be predominantly a backfilled and graded land area restored with indigenous vegetative cover. The only above grade structures remaining per the current plans include the 345 KV switchyard. The former Low-Level Waste Storage Building (now the ISFSI Security Operations Building) will remain in place until the fuel is removed from the ISFSI. Building basements and foundations greater than three feet below grade will be backfilled and left in place. Buried piping that is at least three feet below grade will be remediated as necessary, surveyed, and abandoned in place.

### 6.2.1 Site Geology and Hydrology

The site geology consists of a series of ridges and valleys striking north-south that reflect the competency and structural nature of the underlying bedrock. Deep valleys are filled with glaciomarine clay-silt soil and ridges are characterized by exposed bedrock or thin soil cover over rock. Surface drainage moves both to the north and south along the axes of the topographic valleys and also runs east and west down the flanks of the ridges. In the plant area, where the ground surface is relatively flat, manmade underground storm drains and catch basins control the surface runoff. In the area south of Old Ferry Road, drainage from a large area north of Old Ferry Road and the northern half of Bailey Point discharges in underground manmade piping to Bailey Cove.

The groundwater regime at the Maine Yankee facility is comprised of two aquifers: (1) a discontinuous surficial aquifer in the unconsolidated glaciomarine soils and fill material; and (2) a bedrock aquifer. The surficial aquifer is not present continuously across the site, as the overburden soils are thin to non-existent in some portions of the site. This is especially true in the southern portion of Bailey Point. The bedrock aquifer is present below the entire site and vicinity.

Groundwater originating near the surface in the northern portion of the site generally moves vertically into the soil except in the wetland areas where groundwater discharge locally occurs. After slow movement through the soil, the groundwater moves into the deeper bedrock and travels toward the bay, discharging upward in the near-shore area. In the southern portion of the site, groundwater originating near ground surface generally stays near the surface, rather than penetrating deep into the bedrock.

During plant operation, impacts to the groundwater flow regime were limited to draw-down of the groundwater surface caused by foundation drains around the containment structure and, to a lesser extent, draw-down caused by active water supply wells. The containment structure was dismantled to 3 feet below grade and backfilled. Thus, groundwater levels are expected to recover to approximate pre-construction levels.

### 6.3 Critical Group

The regulations in 10 CFR 20 Subpart E require the dose to be calculated for the average member of the critical group. The critical group is defined in 10CFR20.1003 as “the group of individuals reasonably expected to receive the greatest exposure to residual radioactivity for any applicable set of circumstances.” The average member of the critical group is a conservative approach and is also used for demonstrating compliance with the dose criteria in Maine State Law LD 2688-SP 1084. The critical group selected for the MY site dose assessment is the resident farmer.

The resident farmer is a person who lives on the site after the site is released for unrestricted use and derives all drinking and irrigation water from an onsite well. In addition, a significant portion of the resident’s diet is assumed to be derived from food grown onsite. NRC guidance in NUREG-1727, NUREG-1549, and NUREG-5512 identify the resident farmer as a conservative onsite critical group. 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.

It is unlikely that other future site uses would result in a dose exceeding that calculated for the hypothetical resident farmer. It is more probable that actual future occupants of the site would engage in behaviors that would result in lower doses. For example, it is more likely that a hypothetical future resident would use the municipal water supply, as opposed to well water, since this is the common practice in the vicinity of the site and the yield from onsite test wells has been determined to be low and not suitable for consumption. Further, it is most likely that the site will be limited to industrial use. In this case the future site occupant would be a worker as opposed to the resident farmer. A third example would be an onsite resident who does not derive a significant fraction of

dietary needs from an onsite farm. The important conclusion from these examples is that the dose calculated for the hypothetical resident farmer will likely be a conservative estimate of the dose that an actual site occupant or site visitor would receive.

Maine Yankee has assessed the potential for the filled basements to be excavated and occupied at some time in the future and does not believe that this scenario meets the "reasonable expectation" threshold required by the definition of a critical group in 10 CFR 20.1003. As stated in NUREG-1727, page C26, compliance with the dose limit does not require an investigation of all possible scenarios and the use of the average member of the critical group is intended to emphasize the uncertainty and assumptions needed in calculating potential future dose, while limiting "boundless speculation" on possible future exposure scenarios. As discussed above, selecting the resident farmer critical group is a sufficiently conservative projection of future land use. Further assuming that an individual excavates filled basements and attempts to renovate and occupy the basements is not considered plausible and results in excessive conservatism.

Notwithstanding the very low probability of excavation occurring, Maine Yankee will limit the potential activity on basement fill to concentrations below the surface soil DCGL level corresponding to 10 mrem/y. In addition, cost studies conducted to date indicate that it is more expensive to remediate soil than basement surface contamination. As discussed in Section 6.9, the selected Basement Contamination DCGLs are limited in order to maximize soil DCGL levels. The cost optimization process supported selecting Basement Contamination DCGLs that are below the NRC screening values for standing building surfaces. At these levels, the resident farmer dose for contamination on basement surfaces was shown to be low (per Table 6-11) for any credible future land use.

#### 6.4 Conceptual Model

The Conceptual Model for dose to the resident farmer critical group is different to some extent for each contaminated material due to the different physical characteristics of the materials and different source term radionuclides. The Conceptual Model for each material is described in detail in Section 6.6.

In general, the overall site Conceptual Model includes a resident farmer who lives on the site after release for unrestricted use, draws drinking water and irrigation water from the worst-case onsite well location, and derives a substantial percentage of annual food requirements from the onsite resident farm.

The hypothetical dose from each potentially contaminated material is evaluated independently. However, the total resident farmer dose results from the summation of the contributions from all materials and all pathways. The method for summing the doses and selecting DCGLs for all contaminated materials is provided in Section 6.7.

## 6.5 Environmental Media and Dose Pathways

### 6.5.1 Contaminated Materials

There are nine contaminated materials that could contribute to dose:

- a. Embedded pipe
- b. Buried pipe
- c. Activated concrete/rebar
- d. Groundwater
- e. Surface Water
- f. Basement surfaces
- g. Surface soil
- h. Deep soil
- i. Forebay Sediment

### 6.5.2 Environmental Media

After considering radionuclide transfer from the nine contaminated materials, there are five environmental media that could deliver dose to the resident farmer. These are groundwater, surface soil, deep soil, surface water, and basement fill. Groundwater concentration may increase through the transfer of radionuclides from contaminated basement surfaces, activated concrete/rebar, deep soil, and embedded pipe. Note that the "groundwater" environmental medium includes contributions from water contained in building basements as well as other sources. Basement fill may also become slightly contaminated through the transfer of contamination from basement surfaces, embedded piping, and activated concrete/rebar. Table 6-1 indicates which environmental media are affected by the transfer of radionuclides from contaminated materials.

The residual contamination in the Forebay sediment is not transferred to any of the five environmental media and is evaluated independently. Therefore, Forebay sediment is not included in Table 6-1. The forebay area was released from the 10 CFR 50 License in September 2005.

### 6.5.3 Dose Pathways

The five environmental media listed in Table 6-1 deliver dose to the resident farmer through one or more of the following dose pathways: 1) drinking water; 2) direct exposure; 3) ingesting soil, plants, animals, or fish; and 4) inhaling resuspended soil. These pathways are consistent with those listed in

NUREG-1549 for the resident farmer. A given environmental medium will not contribute dose through all pathways.

Table 6-2 lists the dose pathways applicable to each environmental medium. Note that groundwater contributes to the plant and animal pathways through irrigation.

#### 6.5.4 Radionuclide Concentrations in Environmental Media

To calculate the dose from each pathway the radionuclide concentrations in each environmental medium must be calculated. The concentrations in the surface soil, deep soil, and surface water can be used directly in the dose assessment since there is no contribution from other contaminated materials. However, the final concentrations in groundwater and basement fill, and the resulting dose, will depend on the transfer of contamination from other materials. Final concentrations in the five environmental media are calculated by summing contributions from various materials as listed below.

The contaminated materials that contribute to each of the environmental media are summarized below. The materials in brackets are those requiring transfer evaluations.

- Groundwater Concentration = [basement surface contamination] + [embedded pipe] + [activated concrete/rebar] + [deep soil] + [buried pipe] + existing groundwater concentration
- Basement Fill Concentration = [basement surface contamination] + [embedded pipe] + [activated concrete/rebar]
- Surface Soil Concentration = surface soil concentration
- Deep Soil Concentration = [buried pipe] + deep soil concentration
- Surface Water Concentration = surface water concentration

<b>Table 6-1</b>					
<b>Environmental Media Affected by Transfer from Contaminated Materials</b>					
	<b>Ground Water</b>	<b>Surface Soil</b>	<b>Deep Soil</b>	<b>Surface Water</b>	<b>Basement Fill</b>
<b>Basement Contamination</b>	X				X
<b>Surface Soil</b>		X			
<b>Deep Soil</b>	X		X		
<b>Groundwater</b>	X				
<b>Embedded pipe</b>	X				X
<b>Surface Water</b>				X	
<b>Activated concrete/rebar</b>	X				X
<b>Buried Pipe</b>	X		X		

<b>Table 6-2</b>					
<b>Environmental Media and Dose Pathways for the Resident Farmer Scenario</b>					
	<b>Direct Radiation</b>	<b>Drinking Water</b>	<b>Plant, Animal, Soil Ingestion</b>	<b>Inhalation</b>	<b>Fish Ingestion</b>
<b>Surface Soil</b>	X		X	X	
<b>Deep Soil</b>	X				
<b>Basement Fill</b>	X				
<b>Groundwater</b>		X	X*	X*	
<b>Surface Water</b>		X			X

\* These pathways result through irrigation

## 6.6 Material Specific Dose Assessment Methods and Unitized Dose Factors

Each material has unique characteristics that must be considered when developing the conceptual and mathematical model for dose assessment. This section provides the dose assessment methods and results for each material in a unitized format by expressing the dose as a function of unit concentrations such as 1 dpm/100 cm<sup>2</sup> or 1 pCi/g. The unitized format facilitates the summation of doses from all materials and the selection of material specific DCGLs (see Section 6.7).

### 6.6.1 Contaminated Basement Surfaces

#### a. Conceptual Model

The Dose Model for contaminated basement surfaces assumes that the buildings are demolished to three feet below grade. The remaining basements are then decontaminated as necessary, filled with a suitable material (current plans call for fill with Bank Run Sand or flowable fill) and the area restored to grade, which results in a three-foot cover over the top of the filled basements. After the site is restored, rainwater and groundwater infiltrate into the basements and occupy the void space in the fill material. The available void space volume is a function of the fill material porosity.

The entire inventory of contamination on the basement surfaces, including the concrete and steel liner, is assumed to be instantaneously released and mixed with the water that has infiltrated into the basements. In this context, "surface" is intended to include all radioactivity, at all depths (this does not include activated concrete, which is treated as a separate material). Analyses of Maine Yankee concrete have indicated that, on average, the contamination is about 1 mm deep in the concrete. The liner contamination should be true surface contamination, i.e., not at any significant depth.

Using a mass balance approach, the radionuclides that are released from the surfaces are assumed to instantaneously reach equilibrium between the water, fill, and concrete. The relative equilibrium concentrations in the water, fill, and concrete are a function of the material K<sub>d</sub>, mass, and porosity.

The critical group is the resident farmer who is assumed to drill a domestic water well into the worst case basement, i.e., that with the highest

basement surface area to volume ratio. The amount of activity available for release is assumed to be directly proportional to the surface area of contaminated material. Therefore, the highest surface area/volume ratio results in the maximum radionuclide inventory and maximum concentrations in the water, fill, and concrete. The resident farmer is also assumed to occupy the land immediately above the basement, which maximizes direct exposure through the 3-foot cover. (Since the resident farmer is assumed to receive dose from exposure to surface soil based on 100% stay-time, the additional direct dose from basement fill is a conservative addition to dose. Thus, no credit is taken overall for the absence or presence of the 3 foot cover.)

The conceptual model results in three dose pathways to the resident farmer: 1) drinking water from the well; 2) irrigating with water from the well; and 3) direct radiation from radionuclides in the fill.

b. Mathematical Model

A mathematical model was developed to calculate the equilibrium radionuclide concentrations in the basement water, fill, and concrete after the infiltration of rainwater and groundwater. Contamination is assumed to diffuse into and re-adsorb on concrete surfaces since concrete is a porous media. The re-adsorption on the steel liner is expected to be less than the concrete and is considered to be bounded by the concrete analysis. The mathematical model includes calculations to determine the resident farmer dose from drinking water derived from a well drilled directly into the basement fill, irrigating with the water, and being directly exposed to the covered fill. The model is intended to be a simple, conservative, screening approach.

The radionuclide inventory, water volume, fill volume, and concrete volume subject to re-adsorption are the quantities required to determine the equilibrium radionuclide concentrations in the three materials. The initial condition of the model is that a volume of water has infiltrated into the basement that is equal to the annual volume required for drinking, domestic use, and irrigation by the resident farmer. As stated above, the well is placed directly into the basement fill containing the water. From this initial condition the volumes and masses of the three materials, and the maximum radionuclide inventory released to the water, can be calculated.



The annual resident farmer well-water usage is assumed to be  $738 \text{ m}^3$  (justification provided below). This implies that the fill volume is  $738 \text{ m}^3$  divided by the porosity of the soil, which is assumed to be 0.3 (justification provided below). Therefore, the model fill volume is  $2460 \text{ m}^3$ . This is the minimum fill volume required to contain the annual resident farmer water volume. Depending on the infiltration rate, smaller fill volumes could supply the required  $738 \text{ m}^3/\text{y}$  water volume, but this would result in slightly lower average annual concentrations. Assuming a model volume of  $2460 \text{ m}^3$ , and no dilution through infiltration recharge, is the most conservative approach.

The only areas that remain in the control of the 10 CFR 50 License are those that address the land that the ISFSI sits on and an adjacent parcel of land. The NRC released the other areas from the 10 CFR 50 License. The following information is retained to provide the basis for the model volume.

The actual basement open volumes of the PAB, Spray, and Fuel buildings are less than  $2460 \text{ m}^3$ , but the containment basement volume is greater, i.e.,  $8217 \text{ m}^3$ . The larger containment volume has no effect on the result since the additional hypothetical water volume does not affect the radionuclide concentrations in the water, or the assumed annual water use. In fact, as explained below, using actual containment basement dimensions, including volume and surface area, would reduce water concentrations by a factor of 3.7 since the surface area to volume ratio for the containment basement is lower than that used in the model. The effect of surface area to volume ratio and the rationale for selecting the value used in the model are described below.

The basement surface area to open volume ratios have a direct effect on the results and are necessary for determining two parameters. The most important affected parameter is the maximum radionuclide inventory. Less important, but also related, is the volume of concrete available for re-adsorption of radionuclides. Using the maximum surface area/volume ratio from the four basements maximizes the radionuclide inventory and the resulting water, fill, and concrete concentrations.

The maximum ratio of concrete surface area/basement open volume of  $1.7 \text{ m}^2/\text{m}^3$  is found in the Spray building basement. The surface area/volume ratios for the Containment, PAB, and Fuel buildings are

0.46 m<sup>2</sup>/m<sup>3</sup>, 1.03 m<sup>2</sup>/m<sup>3</sup>, and 0.49 m<sup>2</sup>/m<sup>3</sup>, respectively. Using the maximum ratio of 1.7 m<sup>2</sup>/m<sup>3</sup> results in conservative dose calculations for the Containment, PAB, and Fuel buildings by factors of 3.7, 1.65, and 3.5 respectively. If necessary, as the project proceeds, Maine Yankee may use building-specific surface area/volume ratios based on the data presented in Section 6.6.1(d)(2) to calculate building-specific DCGLs.<sup>1</sup>

Multiplying the 1.7 m<sup>2</sup>/m<sup>3</sup> ratio by the fill volume (2460 m<sup>3</sup>) results in the maximum contaminated surface area that could contribute to the source term for a given 738 m<sup>3</sup> of water. Accordingly, the maximum surface area in the model would be 4182 m<sup>2</sup>, which exceeds the actual surface area of any of the building basements. This occurs because the 1.7 m<sup>2</sup>/m<sup>3</sup> ratio is from the Spray building and the maximum surface area of 3775 m<sup>2</sup> is in the Containment building. However, consistent with a conservative screening approach, and to maintain the correct mathematical relationships between porosity, annual water volume, and surface area, the 4182 m<sup>2</sup> surface area will be used in the model. Note that using 3775 m<sup>2</sup> would reduce the available source term and thereby reduce water concentrations.

Assuming that the water penetrates to a depth of 1 mm in the concrete, the concrete volume available to re-adsorb radionuclides from contaminated water is 4.2 m<sup>3</sup>. The 1 mm depth is based on analyses of contaminated Maine Yankee concrete. Although the conditions are different, i.e., water saturation after decommissioning versus periodic wet contamination events during operation, the penetration of water into the concrete after the basements are filled with water is also assumed to be 1 mm. This is considered a conservative assumption since increasing the concrete penetration depth will decrease the concentrations in the fill and in the water.

The model uses two approximations related to re-adsorption onto concrete that have a very small effect on the final results. First, the fill volume is calculated assuming all of the 738 m<sup>3</sup> water volume is contained in the fill, not mixed between the fill and concrete. An exact solution would require consideration of both the fill and concrete volumes simultaneously. However, the affected concrete volume is very low and the corresponding

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<sup>1</sup> For containment, the building specific SA/V ratio of 0.46 m<sup>2</sup>/m<sup>3</sup> is used for a model surface area of 1130 m<sup>2</sup>

water volume in the concrete is about  $1 \text{ m}^3$ . This is less than 1% of the  $738 \text{ m}^3$  total and is insignificant. Second, the porosity of 0.3 is assumed to apply to both fill and concrete. The same porosities are used in the model in order to produce the simplified solution provided in Equation 7. However, site-specific measurements indicate that the actual concrete porosity is 0.15. Using a porosity of 0.15 would decrease the volume of water in the concrete to about  $0.5 \text{ m}^3$ . An exact solution to these two approximations would have a very small effect on the results and is an unnecessary level of detail considering the conservative screening approach used in the model.

The approach assumes uniform mixing among the soil, water, and concrete. Uniform mixing within the fill is not unreasonable considering the surface area to volume ratio of  $1.7 \text{ m}^2/\text{m}^3$ . Assuming a planar geometry, this means that the water is required to mix over a distance of 0.6 m in the backfill. Although assuming planar geometry is a simplification, it demonstrates that water mixing over long distances in the fill is not intrinsic to the validity of the screening model.

The calculations for determining the equilibrium concentrations in the basement water, fill, and concrete are based on a mass balance approach. The total mass in the system,  $M_t$ , is the sum of the mass in the water ( $M_w$ ), the mass sorbed to the fill ( $M_f$ ), and the mass sorbed to the concrete ( $M_c$ ). For these calculations, mass is expressed as activity,  $A$ . The total activity,  $A_t$ , is the total radionuclide inventory in the  $4182 \text{ m}^2$  basement concrete surface under consideration. Equations (1) through (7) described below are solved for each radionuclide in the Maine Yankee Radionuclide Mixture.

$$A_t = A_w + A_f + A_c \quad (1)$$

Where:  $A_t$  is total activity (pCi)  
 $A_w$  is the total activity in water (pCi)  
 $A_f$  is the total activity in the fill (pCi)  
 $A_c$  is the total activity in the concrete (pCi)

The activity in the water is defined as:

$$A_w = \eta C V_t \quad (2)$$

Where:  $\eta$  is the porosity of the fill and concrete

C is the concentration in solution (pCi/l) and,  
 $V_t$  is the total system volume (sum of the volume of fill and concrete,  $m^3$ ).

At equilibrium the activity adsorbed to the fill and concrete is directly proportional to the concentration in the water. The proportionality constant used in these calculations is the distribution coefficient,  $K_d$ , and has units of  $cm^3/g$ . Distribution coefficients are widely accepted measures of sorption onto the solid phase, and the solid/liquid phase ratio, and are accepted for use in risk assessments by national and international regulatory agencies and scientific organizations including the U.S. Nuclear Regulatory Commission and the U.S. Environmental Protection Agency.

The activity adsorbed on the fill and the concrete can be represented as:

$$A_f = \rho_f K_{d_f} C V_f \quad (3)$$

Where:  $\rho_f$  is fill bulk density ( $g/cm^3$ )  
 $K_{d_f}$  is fill distribution coefficient  
C is water concentration (pCi/l)  
 $V_f$  is fill volume ( $m^3$ )

and

$$A_c = \rho_c K_{d_c} C V_c \quad (4)$$

Where:  $\rho_c$  is concrete bulk density ( $g/cm^3$ )  
 $K_{d_c}$  is concrete distribution coefficient  
C is water concentration (pCi/l)  
 $V_c$  is concrete volume ( $m^3$ )

The bulk density of the fill is assumed to be  $1.5 g/cm^3$  based on analyses of potential fill (reference provided below). For the concrete, a site-specific value of  $2.2 g/cm^3$  was used (reference provided below).  $V$  is the volume of the solid phase;  $V_f$  is  $2460 m^3$  and  $V_c$  is  $4.2 m^3$ .

Combining the terms from Equations (2), (3), and (4) gives:

$$A_t = \eta C V_t + \rho_f K_{d_f} C V_f + \rho_c K_{d_c} C V_c \quad (5)$$

Multiplying the second and third terms by  $(\eta V_i)/(\eta V_i)$ , i.e., 1, and rearranging gives:

$$A_i = \eta C V_i + (\eta V_i C)(\rho_f Kd_f V_f)/(\eta V_i) + (\eta V_i C)(\rho_c Kd_c V_c)/(\eta V_i) \quad (6)$$

Recognizing from Equation (1) that the term,  $\eta C V_i$  is the activity in the water phase,  $A_w$ , allows Equation 6 to be rewritten as:

$$A_i = A_w(1 + \rho_f (Kd_f/\eta)(V_f/V_i) + \rho_c (Kd_c/\eta)(V_c/V_i)) \quad (7)$$

To calculate the water concentration, drinking water dose, concentration in the fill, and concentration on the concrete surfaces, Equation (7) is first solved for  $A_w$ . All of the terms in Equation (7) are known except  $A_w$ . The water concentration,  $C$ , is then calculated using Equation (2). After solving for  $C$ , the backfill and concrete concentrations are calculated using Equations (3) and (4).

#### c. Dose Calculations

The concentrations in the basement water and fill are used to calculate dose. There are three dose pathways to the resident farmer after the fill is placed in the basements, the three-foot cover is completed, and water infiltrates the basements. These are drinking water dose, irrigation dose, and direct dose. The dose calculations are described in Equations (8) through (10). The equations are used to calculate dose for each radionuclide in the Maine Yankee mixture.

There will be no ingestion or inhalation associated with the fill because of the presence of the cover. Ingestion or inhalation could occur if the fill were excavated at some time in the future. To account for this possibility, the projected basement fill concentration is limited to ensure that the concentration will not exceed the surface soil DCGL and that the dose will not increase over that calculated with the earthen cover in place. In fact, the hypothetical dose would decrease if the fill were excavated at some time in the future.

##### 1. Drinking Water Dose

Drinking water dose is calculated from the radionuclide concentrations in the basement water. As shown in Table 6-1, the

basement water is one of several contributors to drinking water dose. The annual water intake is assumed to be 478 L/y consistent with the default values in the NRC screening code, DandD, Version 1. Dose conversion factors are taken from Federal Guidance Report No. 11.

$$\text{Dose}_{\text{dw}} = (C \text{ pCi/l})(478 \text{ L/y})(\text{DCF mrem-y/pCi}) \quad (8)$$

Where: C is water concentration in pCi/L  
DCF is FGR 11 dose conversion factor

## 2. Irrigation Dose

Including irrigation dose is conservative because irrigation in Maine is uncommon due to relatively high annual precipitation. However, consistent with a screening approach it is included. The irrigation rate is assumed to be 0.274 L/m<sup>2</sup>/d (justification provided below). The source of the water is the resident farmer well placed in the building basement. The annual irrigation volume is mixed in a 15 cm depth of soil, which is consistent with the NRC DandD model as described in NUREG-5512, Volume 1. The dose from the resulting soil concentrations were calculated using the NRC screening values in NUREG-1727, Table C2.3, converted to mrem/y per pCi/g.

$$\text{Dose}_{\text{irrigation}} = (C_{\text{soil}} \text{ pCi/g})(\text{NUREG-1727 mrem/y per pCi/g}) \quad (9)$$

Where: Dose<sub>irrigation</sub> is the annual dose from irrigation (mrem/y)  
C<sub>soil</sub> is soil concentration in pCi/g  
(NUREG-1727) is the soil screening value from NUREG-1727, Table C2.3 converted to mrem/y per pCi/g

$$C_{\text{soil}} = \frac{(\text{pCi/L in water})(0.274 \text{ L/m}^2/\text{d})(365 \text{ d})(1 \text{ m}^2)}{(1 \text{ m}^2)(0.15 \text{ m})(1 \text{E}+06 \text{ cm}^3/\text{m}^3)(1.6 \text{ g/cm}^3)} \quad (10)$$

## 3. Direct Dose

The direct dose was calculated using the Microshield code assuming a three-foot soil cover, 10,000 m<sup>2</sup> area, and 5.8 m depth.

The 5.8 m depth represents the deepest basement, i.e., containment. The Microshield result for "Deep Dose Equivalent, Rotational Geometry," was used and is generally referred to as "exposure." The resulting exposure rate was multiplied by the annual outdoor occupancy time of 964 hours ( $0.1101 \times 365 \text{ days} \times 24 \text{ hr/day}$ ) from the NRC DandD, Version 1, screening code to calculate the annual direct exposure dose. The Microshield output reports are provided in Attachment 6-1.

d. Model Input Parameters

The following section describes and justifies the parameters used in the concentration and dose calculations.

1. Distribution Coefficients,  $K_d$

Fill  $K_d$  values were either derived from literature (mean values) or from the results of analyses of site-specific fill materials. The site-specific  $K_d$  analyses were performed by Brookhaven National Laboratory (BNL) (results provided in Attachment 6-2). At this time, the most likely fill material is Bank Run Sand or flowable fill. Therefore, the average  $K_d$ 's for Bank Run Sand or flowable fill from Attachment 6-2 were used in the model. Table 6-3 lists the fill  $K_d$ 's, and the reference, for each radionuclide.

Concrete  $K_d$  values were either derived from literature or from the results of site-specific  $K_d$  analyses. The site-specific  $K_d$  analyses were performed by BNL (results provided in Attachment 6-3). Table 6-3 lists the concrete  $K_d$ 's, and the reference, for each radionuclide. It is seen that for cement, a few  $K_d$ 's were left blank. This indicates data were not available and a value of zero (0) was used in the calculations. A  $K_d$  of zero (0) maximizes the concentration in water. In addition, the Krupka reference did not contain  $K_d$  information for cobalt or iron. It was assumed that the  $K_d$ 's for these two metals were the same as nickel. However, the overall effect of the concrete is small, regardless of  $K_d$ .

<b>Table 6-3</b> <b>Selected Kd Values (cm<sup>3</sup>/g) for Basement Fill Model</b>				
Radionuclide	Mean Flowable Fill Kd	Reference for Mean Kd	Concrete Kd	Reference for Kd in cement
H-3	0		0	
Fe-55	25	Baes, Table 2.13	100	Krupka Table 5.1
Ni-63	128	Attachment 6-2	100	Krupka Table 5.1
Mn-54	50	Sheppard, Table A-1		
Co-57	128	Attachment 6- 2	100	Krupka Table 5.1
Co-60	128	Attachment 6-2	100	Krupka Table 5.1
Cs-134	79	Attachment 6-2	3	Attachment 6-3
Cs-137	79	Attachment 6-2	3	Attachment 6-3
Sr-90	6	Attachment 6-2	1.0	Attachment 6-3
Sb-125	45	Sheppard, Table A-1		
Pu-238	550	Sheppard, Table A-1	5000	Krupka Table 5.1
Pu-239/240	550	Sheppard, Table A-1	5000	Krupka Table 5.1
Pu-241	550	Sheppard, Table A-1	5000	Krupka Table 5.1
Am-241	1900	Sheppard, Table A-1	5000	Krupka Table 5.1
Cm243/244	4000	Sheppard, Table A-1	5000	Krupka Table 5.1
C-14	5	Sheppard, Table A-1		
Eu-152	400	Onishi, Table 8.35		
Eu-154	400	Onishi, Table 8.35		

## 2. Maximum Surface Area to Volume Ratio

The building basements that will remain following demolition of site structures include the Containment, PAB, Spray and Fuel Building basements. The open-air volumes of the basements are 8217 m<sup>3</sup>, 1584 m<sup>3</sup>, 1136 m<sup>3</sup>, and 837 m<sup>3</sup> respectively. This represents the volume of fill required in each basement. The wall and floor surface areas are 3775 m<sup>2</sup>, 1637 m<sup>2</sup>, 1883 m<sup>2</sup>, and 409 m<sup>2</sup>



respectively. The basement volumes and surface areas were determined in Maine Yankee calculation EC 01-00(MY). The maximum surface area to volume ratio of  $1.7 \text{ m}^2/\text{m}^3$  is found in the Spray building basement. This ratio is used in the Unitized Dose Factor tables produced below (Tables 6-4, 5, 6A and 6B). The Containment building surface area to volume ratio of  $0.46 \text{ m}^2/\text{m}^3$  was used in the dose assessment summation for activated concrete (Reference No. 6.10.8) and is shown in Attachment 6-13.

### 3. Porosity

The porosity of the fill material is assumed to be 0.3. The range of mean porosities for a wide variety of soil types are listed in NUREG-5512, Volume 3, "Residual Radioactive Contamination From Decommissioning. Parameter Analysis," Page 6-64, Table 6.41. The porosities listed in NUREG-5512 ranged from 0.36 to 0.49.

The projected dose from contaminated concrete in the basement fill model decreases with increasing porosity. However, the projected doses from the embedded pipe and activated concrete increase with increasing porosity. This is because the source term for embedded and buried piping is constant and the source term for contaminated concrete is a function of surface area. All three dose assessment models are conservative. However, the activated concrete and embedded piping source term assumptions are much more conservative than those used for the basement concrete and the resulting dose is a small fraction of that from contaminated concrete. Therefore, the porosity effect on the contaminated concrete dose is used to select a porosity at the lower end of the range, e.g., 0.3.

### 4. Annual Drinking Water Volume

The annual drinking water volume was assumed to be 478 l/y. This is the default volume from NRC DandD, Version 1 screening code.

### 5. Irrigation Rate and Annual Irrigation Volume

Annual irrigation volume was based on interviews with representatives of the Maine USDA-NRCS. The individuals contacted are documented in a memorandum provided in Attachment 6-4. The USDA representatives indicated that irrigation in Maine is uncommon, but that in drought years irrigation may occur. The Maine USDA representatives indicated that the drought irrigation rate for a family garden would not be expected to exceed 4-5 in/y (10 to 12 cm/y). The 10 cm/y rate was used in the model, which can be converted to 0.274 l/m<sup>2</sup>/d. To calculate total annual volume, the 10 cm/y rate was multiplied by the default cultivated area of 2400 m<sup>2</sup> from the DandD screening model (NUREG-1727, Appendix C, Section 2.3.2). This results in the annual irrigation volume of 240,000 l/y.

#### 6. Annual Domestic Water Use

Annual domestic water volume is derived from NUREG-5512, Volume 3, Page 6-37, Table 6-19. The per capita consumption rate for the State of Maine is listed as 124,422 l/y. Assuming a family of four, this corresponds to a total domestic water volume of 497,688 l/y. The assumption of four occupants is based on the land occupancy rate from NUREG-1727, Table D2, of 0.0004 persons/m<sup>2</sup> and an assumption that the resident farm size is 10,000 m<sup>2</sup>.

#### 7. Total Resident Farmer Annual Well Water Volume

The total annual volume of water from the resident farmer well is the sum of the domestic use plus irrigation use. Domestic use is 497,688 l/y and irrigation use is 240,000 l/y for a total of 737,688 l/y. A rounded value of 738 m<sup>3</sup>/y was used in the model.

#### 8. Concrete Density

Concrete density was determined by site-specific analysis to be 2.2 g/cm<sup>3</sup> (Attachment 6-5).

#### 9. Fill Material Density

Density of the possible fill material is 1.5 g/cm<sup>3</sup> (Attachment 6-2). This corresponds to Bank Run Sand.

#### 10. Soil Density

Density of soil is  $1.6 \text{ g/cm}^3$  based on an average of the densities of Bank Run Sand and Bank Run Gravel from Attachment 6-2. This average is assumed to be representative of the site soil, which is comprised primarily of backfill.

#### 11. Dose Conversion Factors (DCFs)

The DCFs are in units of Committed Effective Dose Equivalent (CEDE) and are taken from Federal Guidance Report No. 11, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," Table 2.2, EPA-520/1-88-020.

#### 12. Outdoor Occupancy Time

The DandD, Version 1, default value of 0.1101 y or 965 hr/y is used.

#### e. Unitized Dose Factors for Contaminated Basement Surfaces

Using Equations 1-10 above, the radionuclide concentrations in basement water, fill, and concrete, and the dose to the resident farmer were calculated using a simple spreadsheet application. The activity of each radionuclide in the Maine Yankee mixture for contaminated surfaces was set to  $1 \text{ dpm/100 cm}^2$  of surface area. The surface was assumed to be concrete for the purpose of the calculation to evaluate the potential effect of re-adsorption on concrete. The spreadsheet output and the resulting unitized dose factors are provided in Table 6-4 (see next page).

#### 6.6.2 Activated Basement Concrete/Rebar

##### a. Conceptual Model

Activated concrete and rebar is present in the ICI sump area in the containment building. The current plan is to remediate activated concrete down to the containment building liner and any rebar associated with this concrete. The walls and floors consist primarily of concrete with rebar being a small percentage. Characterization results indicate that the total activity concentration in rebar is about 1.9 times higher than the concrete surrounding the rebar. In addition, the radionuclide mixtures for concrete and rebar differ as indicated in Table 2-9. However, as shown in Attachment 6-13, the calculated dose from the rebar is less than the dose

from the surrounding concrete (see Table 6-11 for activated concrete dose), accounting for both the higher relative concentration and the rebar radionuclide mixture. Therefore, the walls and floors are conservatively assumed to be comprised entirely of activated concrete in the dose calculation.

**Table 6-4**  
**Contaminated Basement Surfaces Unitized Dose Factors**

**Key Parameters**

Porosity	0.30	Fill Volume	2460.0 m <sup>3</sup>	Annual Total Well Water Vol	738.0 m <sup>3</sup>
Bulk Density	1.50 g/cm <sup>3</sup>	Surface Area/Open Vol	1.70 m <sup>2</sup> /m <sup>3</sup>	Irrigation Rate	0.274 L/m <sup>2</sup> -d
Yearly Drinking Water	478.0 L/yr	Concrete Volume	4.18 m <sup>3</sup>	Surface Soil Depth	0.15 m
Wall Surface Area	4182.0 m <sup>2</sup>	Concrete Density	2.20 g/cm <sup>3</sup>		

DOSE CALCULATION FACTORS				Source Term		Kd		WATER, FILL, CONCRETE CONCENTRATION				CONTAMINATED CONCRETE ANNUAL DOSE				
Nuclide	NUREG-1727 mrem/y per pCi/g	FGR 11 mrem per pCi	Microshield mrem/y per pCi/g	Inventory dpm/100 cm2	Inventory pCi	Kd Fill cm3/gm	Kd Concrete cm3/gm	Adsorption Factor	Water pCi/L	Fill pCi/g	Concrete pCi/g	Nuclide	Drinking Water Dose mrem/y	Irrigation Dose mrem/y	Direct Dose mrem/y	Total Dose mrem/y
Sr-90	1.47E+01	1.42E-04	0.00E+00	1.00E+00	1.88E+05	6.02E+01	1.00E+00	3.02E+02	8.45E-04	5.09E-05	8.45E-07	Sr-90	5.74E-05	5.52E-06	0.00E+00	6.29E-05
Cs-134	4.39E+00	7.33E-05	6.09E-05	1.00E+00	1.88E+05	7.91E+01	3.00E+00	3.96E+02	6.44E-04	5.09E-05	1.93E-06	Cs-134	2.26E-05	1.26E-06	3.10E-09	2.38E-05
Cs-137	2.27E+00	5.00E-05	1.20E-05	1.00E+00	1.88E+05	7.91E+01	3.00E+00	3.96E+02	6.44E-04	5.09E-05	1.93E-06	Cs-137	1.54E-05	6.49E-07	6.11E-10	1.60E-05
Co-60	6.58E+00	2.69E-05	6.30E-04	1.00E+00	1.88E+05	1.28E+02	1.00E+02	6.40E+02	3.98E-04	5.09E-05	3.98E-05	Co-60	5.12E-06	1.16E-06	3.20E-08	6.32E-06
Co-57	1.67E-01	1.18E-06	2.80E-08	1.00E+00	1.88E+05	1.28E+02	1.00E+02	6.40E+02	3.98E-04	5.09E-05	3.98E-05	Co-57	2.25E-07	2.98E-08	1.42E-12	2.54E-07
Fe-55	2.50E-03	6.07E-07	0.00E+00	1.00E+00	1.88E+05	2.50E+01	1.00E+02	1.27E+02	2.01E-03	5.01E-05	2.01E-04	Fe-55	5.82E-07	2.23E-09	0.00E+00	5.84E-07
H-3	2.27E-01	6.40E-08	0.00E+00	1.00E+00	1.88E+05	0.00E+00	0.00E+00	1.00E+00	2.55E-01	0.00E+00	0.00E+00	H-3	7.80E-06	2.57E-05	0.00E+00	3.35E-05
Ni-63	1.19E-02	5.77E-07	0.00E+00	1.00E+00	1.88E+05	1.28E+02	1.00E+02	6.40E+02	3.98E-04	5.09E-05	3.98E-05	Ni-63	1.10E-07	2.11E-09	0.00E+00	1.12E-07

With the exception of the source term calculation, and the realistic release rate to the basement, the conceptual model for activated concrete is identical to the conceptual model for contaminated basement surfaces described above. See Reference 6.10.7 for a discussion of the activated concrete dose model.

b. Dose Factors for Activated Concrete

Although activated concrete is present at depth beneath the surface, the dose calculation for activated concrete is based on a total activity (sum of all radionuclides) in the floors and walls of the ICI sump. The total inventory, i.e., source term, includes the radionuclides in the entire volume of activated concrete, including surface and subsurface. The total inventory was determined to be  $4.88\text{E}+08$  pCi as described in Reference 6.10.7.

To determine the inventory of each radionuclide, the total  $4.88\text{E}+08$  pCi inventory must be multiplied by the radionuclide fraction in the activated concrete mixture. The resulting radionuclide specific inventories are input to the "inventory" column in the spreadsheet developed for the contaminated basement surfaces. All of the resulting water, fill, and concrete concentrations and dose calculations are identical to those described for the contaminated basement surfaces in Section 6.6.1.

Table 6-5 - Deleted

### 6.6.3 Embedded Pipe

#### a. Conceptual Model

Embedded pipe includes pipes that are encased in the basement concrete walls or floors that will remain after demolition and remediation. The conceptual dose model is identical to that described for contaminated basement surfaces. However, analogous to activated concrete, the source term calculation includes the entire radionuclide inventory contained in all embedded piping, regardless of location. The entire inventory is assumed to be instantaneously released into the worst case 738 m<sup>3</sup> of basement water.

#### b. Unitized Dose Factors for Embedded Pipe

The total embedded pipe inventory is calculated assuming a unit contamination level of 1 dpm/100 cm<sup>2</sup> over the entire internal surface area of all embedded pipe remaining after decommissioning. A list of the embedded piping planned to remain after decommissioning is provided in Attachment 6-7. The internal surface area of the embedded piping is 154 m<sup>2</sup>. Assuming a unit inventory of 1 dpm/100 cm<sup>2</sup> the total inventory was determined to be 6.95E+03 pCi. The 6.95E+03 pCi inventory applies to each radionuclide at a "unit" concentration of 1 dpm/100 cm<sup>2</sup>. Based on this value, an inventory was calculated and input into the spreadsheet developed for the contaminated basement surfaces. The spreadsheet "inventory" column input was calculated by multiplying the pipe surface contamination level, in this case a unitized level of 1 dpm/100 cm<sup>2</sup>, by the 6.95E+03 pCi unit inventory. Because two distinct areas (Embedded Spray Pump Piping and BOP Embedded Piping) were created to address embedded piping, two different DCGL calculations (and spreadsheets) were created. Each spreadsheet addresses separate unit inventories that sum to the above total inventory (Spray Pump and BOP embedded inventories are 1.19E+03 and 5.75E+03 respectively). These forms facilitate the use of the spreadsheets in the total dose and DCGL calculations provided in Section 6.7. All of the resulting water, fill, and concrete concentrations, and dose calculations are identical to those described for the contaminated basement surfaces in Section 6.6.1.

The BOP Embedded Piping and Embedded Spray Pump Piping spreadsheets are provided in Tables 6-6A and 6-6B. The results represent the unit dose factors for embedded piping assuming a source term of 1 dpm/100 cm<sup>2</sup>, for each radionuclide, on the internal surfaces of the associated pipe.

**Table 6-6A**  
**BOP Embedded Piping Unitized Dose Factors**  
**Key Parameters**

Porosity	0.30	Fill Volume	2460.0 m <sup>3</sup>	Surface Soil Depth	0.15 m
Bulk Density	1.50 g/cm <sup>3</sup>	Surface Area/Open Vol	1.70 m <sup>2</sup> /m <sup>3</sup>	Irrigation Rate	0.274 L/m <sup>2</sup> -d
Yearly Drinking Water	478.0 l/yr	Concrete Volume	4.18 m <sup>3</sup>	Annual Total Well Water Vol	738 m <sup>3</sup>
Wall Surface Area	4182.0 m <sup>2</sup>	Concrete Density	2.20 g/cm <sup>3</sup>	Embedded Pipe Conversion Factor	5754.5 pCi per dpm/100 cm <sup>2</sup>
				Total Inventory	1.00E+00 dpm/100 cm <sup>2</sup>

DOSE CALCULATION FACTORS				Source Term		Kd		WATER, FILL, CONCRETE CONCENTRATION				EMBEDDED PIPE ANNUAL DOSE				
Nuclide	NUREG-1727 mrem/y per pCi/g	FGR 11 mrem/pCi	Microshield mrem/y per pCi/g	Inventory dpm/100 cm <sup>2</sup>	Inventory pCi	Kd Fill cm <sup>3</sup> /gm	Kd Concrete cm <sup>3</sup> /gm	Adsorption Factor	Water pCi/L	Fill pCi/g	Concrete pCi/g	Nuclide	Drinking Water Dose mrem/y	Irrigation Dose mrem/y	Direct Dose mrem/y	Total Dose mrem/y
Sr-90	1.47E+01	1.42E-04	0.00E+00	1.00E+00	5.75E+03	6.02E+01	1.00E+00	3.01E+02	2.58E-05	1.55E-06	2.58E-08	Sr-90	1.75E-06	1.69E-07	0.00E+00	1.92E-06
Cs-134	4.39E+00	7.33E-05	6.09E-05	1.00E+00	5.75E+03	7.91E+01	3.00E+00	3.98E+02	1.97E-05	1.56E-06	5.90E-08	Cs-134	6.89E-07	3.84E-08	9.47E-11	7.27E-07
Cs-137	2.27E+00	5.00E-05	1.20E-05	1.00E+00	5.75E+03	7.91E+01	3.00E+00	3.98E+02	1.97E-05	1.56E-06	5.90E-08	Cs-137	4.70E-07	1.98E-08	1.87E-11	4.90E-07
Co-60	6.58E+00	2.69E-05	6.30E-04	1.00E+00	5.75E+03	1.28E+02	1.00E+02	6.40E+02	1.22E-05	1.55E-06	1.22E-06	Co-60	1.56E-07	3.56E-08	9.79E-10	1.93E-07
Co-57	1.67E-01	1.18E-06	2.80E-08	1.00E+00	5.75E+03	1.28E+02	1.00E+02	6.40E+02	1.22E-05	1.55E-06	1.22E-06	Co-57	6.86E-09	9.03E-10	4.35E-14	7.76E-09
Fe-55	2.50E-03	6.07E-07	0.00E+00	1.00E+00	5.75E+03	2.50E+01	1.00E+02	1.27E+02	6.13E-05	1.53E-06	6.13E-06	Fe-55	1.78E-08	6.81E-11	0.00E+00	1.78E-08
H-3	2.27E-01	6.40E-08	0.00E+00	1.00E+00	5.75E+03	0.00E+00	0.00E+00	1.00E+00	7.78E-03	0.00E+00	0.00E+00	H-3	2.38E-07	7.85E-07	0.00E+00	1.02E-06
Ni-63	1.19E-02	5.77E-07	0.00E+00	1.00E+00	5.75E+03	1.28E+02	1.00E+02	6.40E+02	1.22E-05	1.55E-06	1.22E-06	Ni-63	3.35E-09	6.43E-11	0.00E+00	3.42E-09



**Table 6-6B**  
**Embedded Spray Pump Piping Unitized Dose Factors**

**Key Parameters**

Porosity	0.30	Fill Volume	2460.0 m <sup>3</sup>	Surface Soil Depth	0.15 m
Bulk Density	1.50 g/cm <sup>3</sup>	Surface Area/Open Vol	1.70 m <sup>2</sup> /m <sup>3</sup>	Irrigation Rate	0.274 L/m <sup>2</sup> -d
Yearly Drinking Water	478.0 l/yr	Concrete Volume	4.18 m <sup>3</sup>	Annual Total Well Water Vol	738 m <sup>3</sup>
Wall Surface Area	4182.0 m <sup>2</sup>	Concrete Density	2.20 g/cm <sup>3</sup>	Embedded Pipe Conversion Factor	1191.7 pCi per dpm/100 cm <sup>2</sup>
				Total Inventory	1.00E+00 dpm/100 cm <sup>2</sup>

DOSE CALCULATION FACTORS				SOURCE TERM		Kd		WATER, FILL, CONCRETE CONCENTRATION				EMBEDDED PIPE ANNUAL DOSE				
Nuclide	NUREG-1727 mrem/y per pCi/g	FGR 11 mrem/pCi	Microshield mrem/y per pCi/g	Inventory dpm/100 cm <sup>2</sup>	Inventory pCi	Kd Fill cm <sup>3</sup> /gm	Kd Concrete cm <sup>3</sup> /gm	Adsorption Factor	Water pCi/L	Fill pCi/g	Concrete pCi/g	Nuclide	Drinking Water Dose mrem/y	Irrigation Dose mrem/y	Direct Dose mrem/y	Total Dose mrem/y
Sr-90	1.47E+01	1.42E-04	0.00E+00	1.00E+00	1.19E+03	6.02E+01	1.00E+00	3.01E+02	5.35E-06	3.22E-07	5.35E-09	Sr-90	3.63E-07	3.50E-08	0.00E+00	3.98E-07
Cs-134	4.39E+00	7.33E-05	6.09E-05	1.00E+00	1.19E+03	7.91E+01	3.00E+00	3.96E+02	4.07E-06	3.22E-07	1.22E-08	Cs-134	1.43E-07	7.95E-09	1.96E-11	1.51E-07
Cs-137	2.27E+00	5.00E-05	1.20E-05	1.00E+00	1.19E+03	7.91E+01	3.00E+00	3.96E+02	4.07E-06	3.22E-07	1.22E-08	Cs-137	9.73E-08	4.11E-09	3.87E-12	1.01E-07
Co-60	6.58E+00	2.69E-05	6.30E-04	1.00E+00	1.19E+03	1.28E+02	1.00E+02	6.40E+02	2.52E-06	3.22E-07	2.52E-07	Co-60	3.24E-08	7.37E-09	2.03E-10	4.00E-08
Co-57	1.67E-01	1.18E-06	2.80E-08	1.00E+00	1.19E+03	1.28E+02	1.00E+02	6.40E+02	2.52E-06	3.22E-07	2.52E-07	Co-57	1.42E-09	1.87E-10	9.01E-15	1.61E-09
Fe-55	2.50E-03	6.07E-07	0.00E+00	1.00E+00	1.19E+03	2.50E+01	1.00E+02	1.27E+02	1.27E-05	3.17E-07	1.27E-06	Fe-55	3.68E-09	1.41E-11	0.00E+00	3.70E-09
H-3	2.27E-01	6.40E-08	0.00E+00	1.00E+00	1.19E+03	0.00E+00	0.00E+00	1.00E+00	1.61E-03	0.00E+00	0.00E+00	H-3	4.93E-08	1.63E-07	0.00E+00	2.12E-07
Ni-63	1.19E-02	5.77E-07	0.00E+00	1.00E+00	1.19E+03	1.28E+02	1.00E+02	6.40E+02	2.52E-06	3.22E-07	2.52E-07	Ni-63	6.95E-10	1.33E-11	0.00E+00	7.08E-10

#### 6.6.4 Surface Soil

##### a. Conceptual Model

Surface soil includes all soil within the first 15 cm of the ground surface. The NRC screening values for soil from NUREG-1727, Table C2.3, are used for the unitized dose calculations. Therefore, the conceptual model is identical to that described in NUREG-1727. The screening values include the dose from all pathways. The groundwater contribution to the screening value dose is negligible and is entered as zero. The screening values are used because they were specifically generated by NRC to be conservative calculations of the resident farmer dose and are recommended for use in NUREG-1727.

Verification Conditions (for Surface Soil Screening Values). NUREG-1727, NMSS Decommissioning Standard Review Plan, Appendix C, describes the justification necessary to allow direct use of these screening. Per the NUREG, the following conditions must be satisfied:

1. The initial residual radioactivity (after decommissioning) is contained in the top layer of the surface soil [that is, approximately 6 inches (15cm)].
2. The unsaturated zone and the groundwater are initially free of contamination.
3. The vertical saturated hydraulic conductivity at the specific site is greater than the infiltration rate.

The above conditions are satisfied for the Maine Yankee site.

Condition One. The direct use of these screening values is only for surface soil (approx. 6 inches). Section 6.6.5 calculated a dose from deep soil (that is, greater than 6 inches) separate from the use of the surface soil screening values. (See Section 6.6.5)

Condition Two. Maine Yankee does not use the surface soil screening values to address potential site groundwater contamination from H-3. H-3 presence in the groundwater and surface water is assumed based upon the highest measured readings and is covered by separate dose assessments. (See Sections 6.6.6 and 6.6.7)

Condition Three. The soils at Maine Yankee that are in areas currently containing nuclides elevated above background, and those soils that are planned to be used to fill the foundations are bank run sand and gravel. The Adams or Hinckley USDA Soil Series would provide the closest approximation. The minimum saturated vertical hydraulic conductivity of these soils is 0.001 cm/sec or 1.417 inches per hour. Average saturated hydraulic conductivity rates would be about 10 times this, or 14 inches per hour. Infiltration capacity is based on land cover type, antecedent moisture condition prior to a rainfall or snowmelt event, and the rate of water supply available for infiltration. The permanent water table at the Maine Yankee site in the area of interest is approximately elevation 10 to 15 feet above Mean Sea Level, indicating a distance of 6 to 11 feet from the existing ground surface to the average water table position. Therefore, this much of the sand fill will be unsaturated. Infiltration capacity is limited by the unsaturated hydraulic conductivity of the soil. The unsaturated hydraulic conductivity of the sand fill is typically from 1/10 to 1/100 of the saturated hydraulic conductivity. Precipitation rates rarely exceed one inch per hour in Maine. Therefore, because the typically expected maximum precipitation rate is less than the minimum saturated hydraulic conductivity, and because the fill is unsaturated for 6 or more feet down and unable to transmit water downward at a rate exceeding the saturated vertical hydraulic conductivity, infiltration rates in the fill must be less than the saturated vertical hydraulic conductivity.

Soil types on the Maine Yankee site are representative of those assumed in the soil screening model. These soil types include: silt loams derived from glaciomarine sediments, fine sandy loams derived from glacial till, and fill that has a wide textural variation. However, the primary fill in the immediate plant area is a sand or loamy sand. The silt loams are most typical over the undisturbed portions of the site. The exceptions are in the knoll and ridge areas where bedrock is exposed or shallow where the fine sandy loams predominate. Fill areas surrounding the plant buildings are sand or loamy sand. Fill areas north of the 345 KV yard tend to have a silt loam surface covering. The most likely foundation fill material will be bank run sand. (See Section 6.6.1d.)

b. Unitized Dose Factors for Surface Soil

The unitized dose factors are generated for each radionuclide directly from the NUREG-1727 screening values by converting the values to mrem/y per pCi/g. Table 6-7 provides the "Surface Soil" unitized dose spreadsheet. The results represent the dose from a unit source term if 1 pCi/g for each radionuclide in the soil mixture.

<p align="center"><b>Table 6-7</b> <b>Surface Soil Unitized Dose Factors 1.0 pCi/g Cs-137</b></p>			
<p><b>Key Parameters:</b></p> <p><b>Soil Depth      0.15 m</b></p>			
DOSE CALCULATION FACTORS		SOURCE TERM	SURFACE SOIL ANNUAL DOSE
Nuclide	NUREG-1727 mrem/y per pCi/g	Soil pCi/g	Total Dose mrem/yr
Cs-137	2.27E+00	1.00E+00	2.27E+00
Co-60	6.58E+00	1.00E+00	6.58E+00
H-3	2.27E-01	1.00E+00	2.27E-01
Ni-63	1.19E-02	1.00E+00	1.19E-02

#### 6.6.5 Deep Soil

##### a. Conceptual Model

Deep soil is defined as soil at depths greater than 15 cm. A separate calculation is required for deep soil because the NRC soil screening values apply to the top 15 cm of soil only. The resident farmer is exposed to deep soil through the direct exposure pathway and groundwater. The deep soil could be brought to the surface at some time in the future through the activities of the resident farmer. Therefore, the deep soil concentration will be limited to the surface soil DCGL.

The conceptual model for deep soil assumes a 15 cm layer of uncontaminated soil for the purpose of calculating the additional direct radiation exposure. The 15 cm cover represents the layer of surface soil. The direct radiation from residual contamination in the top 15 cm soil layer was accounted for in the surface soil screening values. A very large volumetric source term was assumed, i.e., 28,500 m<sup>3</sup>, for the purpose of conservatively determining the potential for groundwater contamination from deep soil. This is considered a bounding source term volume and essentially represents the entire volume of soil within the restricted area down to bedrock. After remediation and backfill, the actual remaining volume of deep soil with any significant contamination will be a very small fraction of 28,500 m<sup>3</sup>.

b. Unitized Dose Factors for Deep Soil

Unitized dose factors were calculated using unit concentrations of each of the radionuclides in the soil mixture. The contribution from direct radiation was calculated using the Microshield code assuming a 15 cm cover and default values from DandD for indoor occupancy time (0.6571 y), outdoor occupancy time (0.1101 y), and external radiation shielding factor (0.5512). The Microshield output reports, deep dose direct radiation calculations, and resulting dose factors are provided in Attachment 6-8.

The maximum groundwater concentrations were calculated using RESRAD and unit concentrations of each radionuclide in the mixture. The RESRAD groundwater parameters used in the analysis are listed in Table 6-8. Only the parameters pertaining to groundwater transport are listed since the groundwater concentration is the only RESRAD output used. The RESRAD parameters affecting groundwater transport were reviewed by a local hydrologist who is very familiar with the site hydrogeological characteristics (Mr. Robert Gerber, P.E. and Certified Geologist). The parameters in Table 6-3 are recommended site-specific values. The Kd's were derived from Maine Yankee analyses of Bank Run Sand and Bank Run Gravel. The average of these two materials was assumed to represent the material used to backfill the site during plant construction. Finally, site-specific effective porosity was identified as variable at the site. To account for this variability, a sensitivity analysis was conducted over a range of 0.01 to 0.001. The highest groundwater concentration resulted from a value of 0.01, which was used in the analysis.

Table 6-8 Site Specific Parameters used in RESRAD Deep Soil Analysis			
Parameter		Value	Units
Contaminated Zone site specific hydraulic conductivity		32	m/y
Contaminated Zone site specific b factor		4.05	
Site Specific Effective Porosity		0.01	
Unsaturated. Zone Site Specific Hydraulic Conductivity		1000	m/y
Site Specific Soil Kds:	Co	335.0	cm <sup>3</sup> /g
	Sr	152.0	cm <sup>3</sup> /g
	Cs	1200.0	cm <sup>3</sup> /g
	Ni	274.0	cm <sup>3</sup> /g

Attachment 6-9 provides the RESRAD output report. The attachment provides the results for the radionuclides that were projected to migrate to groundwater over a 1000 year period. The RESRAD code was used only to estimate maximum groundwater concentrations, not calculate dose. The dose from the groundwater concentrations listed in Attachment 6-9 were calculated using the same parameters as in the water dose calculations performed for contaminated basement surfaces, activated concrete/rebar, and embedded piping, i.e, 478 l/y annual water intake and FGR 11 Dose Factors. The spreadsheet output and the unitized dose factors for deep soil are provided in Table 6-9.

Table 6-9 Deep Soil Unitized Dose Factors										
Key Parameters										
Porosity	0.3			Yearly Drinking Water	478	L/y	Surface Soil Depth	0.15	m	
Bulk Density	1.6	g/cm <sup>3</sup>		Irrigation Rate	0.274	L/m <sup>2</sup> -d				
DOSE CALCULATION FACTORS				Source Term			DEEP SOIL ANNUAL DOSE			
Nuclide	NUREG-1727 mrem/y per pCi/g	FGR 11 mrem/pCi	Microshield mrem/y per pCi/g	Deep Soil Inventory pCi/g	Derived Water Conversion Units pCi/L per pCi/g	Water Inventory pCi/L	Drinking Water Dose mrem/y	Irrigation Dose mrem/y	Direct Dose mrem/y	Total Dose mrem/y
Cs-137	2.27E+00	5.00E-05	4.00E-01	1.00E+00	9.02E-03	9.02E-03	2.16E-04	8.53E-06	4.00E-01	4.00E-01
Co-60	6.58E+00	2.69E-05	2.40E+00	1.00E+00	2.24E-02	2.24E-02	2.88E-04	6.15E-05	2.40E+00	2.40E+00
H-3	2.27E-01	6.40E-08	0.00E+00	1.00E+00	6.69E+03	6.69E+03	2.05E-01	6.33E-01	0.00E+00	8.37E-01
Ni-63	1.19E-02	5.77E-07	0.00E+00	1.00E+00	6.01E-01	6.01E-01	1.66E-04	2.98E-06	0.00E+00	1.69E-04

#### 6.6.6 Groundwater

This calculation applies to existing groundwater only. As described above, there are additional contributions to the projected total groundwater dose from other contaminated materials.

Groundwater dose is calculated directly from the highest individual groundwater sample result from site monitoring well locations. As reported in Section 2, Attachment B, the only radionuclide identified in site groundwater is H-3 and the maximum concentration was identified in the containment foundation sump at a concentration of 6812 pCi/l. The range of H-3 concentrations identified during characterization sampling of site wells was 441 pCi/l to 6812 pCi/l, for the most part consistent with background levels. The containment sump was re-sampled during

continued characterization with 900 pCi/l H-3 identified. In addition, routine containment sump water samples were collected. None of these samples exceeded the MDC level of about 2500 pCi/l. (Additional sampling and analyses of site groundwater conducted in 2002, including the containment foundation sump, are discussed in Section 2.5.3.d and reported to the NRC in references noted in that section. The additional sampling confirmed the nuclide fraction and conservatism of the H-3 activity level assumed in the dose assessment.)

In general, it appears that current containment sump H-3 water concentrations are within the range expected in area water background. However, to ensure that a conservative water concentration is applied and to avoid the potentially extensive sampling and analyses necessary to demonstrate that the concentrations are at background levels, the 6812 pCi/l H-3 concentration is used in the dose assessment. If, prior to unrestricted release of the site, additional groundwater monitoring data are collected that indicate higher H-3 concentration, or identify other radionuclides, the higher concentrations will be used in the final dose assessment for demonstrating compliance with the 10/4 mrem/yr dose limit.

As discussed in Section 2.5.3.d, additional routine sampling of the containment foundation sump and PAB test pit will be conducted routinely until final status survey has commenced in these two plant areas. The samples will be taken on an approximate monthly basis and will be analyzed by gamma spectroscopy and for H-3. Sample analysis results will be evaluated regarding: (1) the need for additional assessment (such as, additional sampling or "hard to detect" analyses) and (2) any impact to the dose assessment.

There are no unit dose factors or DCGLs for groundwater. The actual dose from the highest measured concentration will be used in the total dose calculation. The groundwater dose is calculated using the FGR 11 DCF for H-3 and a 478 l/y intake. The resulting dose is 0.21 mrem/y. The method for factoring the groundwater dose into the total dose calculation and the DCGL determination for other contaminated materials is described in Section 6.7.

The dose calculation for existing groundwater is provided below.

$$\text{Dose}_{\text{GW}} = (6812 \text{ pCi/l H-3})(478 \text{ l/y})(6.4\text{E-}08 \text{ mrem/y/pCi}) = 0.21 \text{ mrem/y} \quad (12)$$

#### 6.6.7 Surface Water

Site surface water from the Fire Pond and Reflecting Pond was sampled during characterization. The results indicated no plant derived radionuclides in the Fire Pond and a low potential in the Reflecting Pond. Therefore, only the Reflecting Pond was considered in the dose assessment.

Tritium was detected in the Reflecting Pond at a maximum concentration of 960 pCi/l. This activity is not believed to be attributable to Maine Yankee operations. However, a review of available literature on H-3 concentrations in surface water could not conservatively demonstrate that the H-3 concentrations identified were consistent with background levels in the region. Additional characterization and literature review may provide the information needed to demonstrate that the H-3 was not plant derived. However, given the very low dose from these H-3 concentrations, it was not considered cost effective to perform more analyses.

As for groundwater, the dose from surface water was calculated using existing data. The maximum H-3 concentration of 960 pCi/l was used. As with groundwater, if higher concentrations or additional radionuclides are identified at any time prior to unrestricted release of the facility, the higher concentrations will be used in the final dose assessment for demonstrating compliance.

The surface water dose results from drinking water and ingesting fish from the pond. The water dose is calculated using the parameters described above assuming that the resident farmer drinks directly from the surface water source. The dose from fish ingestion is calculated using a water to fish transfer factor of 1 for H-3 (NUREG-5512, Vol. 3, Table 6.30), 20.6 kg fish consumption per year (DandD default value), and using DCFs from FGR No.11.

The calculations for water and fish consumption from onsite surface water with a H-3 concentration of 960 pCi/l is provided below.

$$\text{Dose}_{\text{sw}} = (960 \text{ pCi/l H-3})(478 \text{ l/y})(6.4\text{E-}08 \text{ mrem/y/pCi}) = 2.9\text{E-}02 \text{ mrem/y} \quad (13)$$

$$\text{Dose}_{\text{Fish}} = (960 \text{ pCi/l})(1.0 \text{ pCi/kg per pCi/l})(20.6 \text{ kg/y})(6.4\text{E-}08 \text{ mrem/y/pCi}) = 1.3\text{E-}03 \text{ mrem/y} \quad (14)$$

#### 6.6.8 Buried Piping

##### a. Conceptual Model

After decommissioning is completed, some piping and conduit will remain underground at depths greater than three feet below grade. This contaminated material category includes the piping buried in open land, not pipe embedded in concrete basements, which were described in Section 6.6.3. A list of the buried piping that current plans call to remain after decommissioning is provided in Attachment 6-10. The buried piping is expected to contain very



limited levels of contamination, if any. The radionuclide mixture is assumed to be the same as for contaminated materials.

The conceptual dose model for the buried piping is very simple and conservative. The piping/conduit is assumed to be uniformly contaminated over the entire internal surface area. The piping is further assumed to eventually disintegrate resulting in the total inventory in the pipe mixing with a volume of soil equal to the pipe volume. Without the assumption of the pipe disintegrating, there is essentially no dose pathway from buried piping. The resulting calculated soil concentrations are treated as deep soil and the dose was calculated using the same methods as described above for deep soil. However, the direct exposure is calculated assuming a three foot cover as opposed to a 15 cm cover. Although not required by the conceptual model, the buried piping DCGLs will be limited to ensure that the projected soil concentrations are below the surface soil DCGLs. This additional measure of conservatism was also applied to deep soil to account for hypothetical future excavation of the buried contamination.

b. Unitized Dose Factors for Buried Piping

The total surface area and total volume were calculated for all of the buried piping planned to remain after decommissioning. Assuming a unit inventory of 1 dpm/100 cm<sup>2</sup> on the internal surfaces, the total inventory of each radionuclide was determined. This total inventory was divided by the total volume and converted to grams of soil assuming a density of 1.6 g/cm<sup>3</sup> to calculate the projected pCi/g soil concentration of each radionuclide. The list of Buried Piping and the calculation of projected pCi/g soil concentration are provided in Attachment 6-10. The resulting concentration is 2.59E-04 pCi/g.

The resulting projected pCi/g soil concentration was entered as the source term in RESRAD for each applicable radionuclide. The RESRAD analysis was performed using the same parameters used for deep soil (Table 6-8) with the exception of the source term geometry. For the buried piping, the source term geometry was assumed to be a 142 m<sup>2</sup> area 1 m deep. This corresponds to the total volume of all buried piping of 142 m<sup>3</sup>. This is a conservative assumption since, in reality, the piping is distributed over a fairly large surface area which would result in dilution through groundwater transport compared to the maximum concentration assuming all the pipe is contiguous. The RESRAD output report is provided in Attachment 6-11.

Microshield runs were performed on the unit source term assuming the same 142 m<sup>2</sup> x 1m deep source. The source is assumed to be covered by three feet of soil. The resulting exposure rate was multiplied by the default outdoor occupancy time (0.1101 y) from DandD, Version 1. The Microshield reports

**Table 6-10**  
**Buried Piping Unitized Dose Factors**

Key Parameters											
Porosity	0.3			Yearly Drinking Water			478	L/y			
Bulk Density	1.6 g/cm <sup>3</sup>			Irrigation Rate			0.274	L/m <sup>2</sup> -d			
Buried Pipe Conversion Factor	2.59E-04 pCi/g per dpm/100 cm <sup>2</sup>			Surface Soil Depth			0.15	m			
Dose Calculation Factors				Source Term			Buried Piping Annual Dose				
Nuclide	FGR 11 mrem/pCi	NUREG-1727 mrem/y per pCi/g	Microshield mrem/y per pCi/g	Water Inventory pCi/L per pCi/g	Pipe Surface Inventory dpm/100cm2	Soil Inventory pCi/g	Drinking Water Dose mrem/y	Irrigation Dose mrem/y	Direct Dose mrem/y	Total Dose mrem/y	
Sr-90	1.42E-04	1.47E+01	0.00E+00	2.15E-02	1.00E+00	2.59E-04	3.77E-07	3.41E-08	0.00E+00	4.12E-07	
Cs-134	7.33E-05	4.39E+00	2.21E-05	2.25E-05	1.00E+00	2.59E-04	2.04E-10	1.07E-11	5.72E-09	5.94E-09	
Cs-137	5.00E-05	2.27E+00	3.97E-06	3.27E-04	1.00E+00	2.59E-04	2.02E-09	8.01E-11	1.03E-09	3.13E-09	
Co-60	2.69E-05	6.58E+00	2.53E-04	8.14E-04	1.00E+00	2.59E-04	2.71E-09	5.78E-10	6.55E-08	6.88E-08	
Co-57	1.18E-06	1.67E-01	9.44E-09	1.15E-04	1.00E+00	2.59E-04	1.68E-11	2.07E-12	2.45E-12	2.13E-11	
Fe-55	6.07E-07	2.50E-03	0.00E+00	4.30E-05	1.00E+00	2.59E-04	3.23E-12	1.16E-14	0.00E+00	3.24E-12	
H-3	6.40E-08	2.27E-01	0.00E+00	1.98E+02	1.00E+00	2.59E-04	1.57E-06	4.85E-06	0.00E+00	6.42E-06	
Ni-63	5.77E-07	1.19E-02	0.00E+00	2.09E-02	1.00E+00	2.59E-04	1.49E-09	2.68E-11	0.00E+00	1.52E-09	

and Buried Piping Direct Radiation Dose Factors are provided in Attachment 6-12. The spreadsheet output and resulting unitized dose factors (1 dpm/100 cm<sup>2</sup>) for buried piping are provided in Table 6-10.

#### 6.6.9 Forebay and Diffuser

The NRC released the area associated with the Forebay and Diffuser from the 10 CFR 50 license on September 30, 2005.

**Table 6-10A**  
**Deleted**

**Table 6-10B**  
**Deleted**

#### 6.6.10 Circulating Water Pump House

The NRC released the area associated with the Circulating Water Pump House from the 10 CFR 50 license on September 30, 2005

#### 6.7 Material Specific DCGLs and Total Dose Calculation

As described above, calculations were performed to develop conservative dose assessment models and generate unitized dose factors for all contaminated materials at the Maine Yankee site and all radionuclides in the Maine Yankee mixture applicable to each material. When the dose pathways for the resident farmer were evaluated, it was evident that the resident farmer could receive dose from more than one contaminated material. A detailed discussion of the various contaminated materials and dose pathways was provided above. The total dose results from the summation of the contributions from each of contaminated materials. Therefore, the final DCGLs for each of the contaminated materials are inter-dependent.

This section describes the method used to account for the dose from all materials and select the final DCGLs for all materials. The method ensures that the summation of doses from all pathways, at the selected DCGL concentrations for all materials, does not exceed 4 mrem/y drinking water dose and 10 mrem/y total dose. Table 6-11 provides the DCGLs that were selected for the Maine Yankee Site and the resulting total dose for all contaminated materials. (Since the containment basement was the only remaining basement structure to be directly impacted by activated concrete, the basement fill dose calculations were treated in two approaches. One assessment was performed for the containment basement, accounting for the direct impact of the activated concrete present. A second assessment was performed, conservatively modeling the remaining non-containment basement structures. The results are presented in Table 6-11, which comprises two tables: one for containment (Table 6-11a) and one for non-containment (Table 6-11b). For additional discussion on the dose assessment related to activated concrete, see the request for license amendment in Reference 6.10.7, which was approved by the NRC in Reference 6.10.8 ).

Attachment 6-13 contains the dose calculations for all contaminated materials listed in Table 6-11. The radionuclide mixture for "special areas" differs from the rest of the basement surfaces. Therefore, a separate DCGL was selected and a separate dose calculation was performed for the "special areas". (See Attachment 2F for a discussion of "special areas".)

The DCGLs listed in Table 6-11 are target project DCGLs. The formal unrestricted use criteria are the enhanced State dose criteria of 10 mrem/y or less from all pathways and 4 mrem/y or less from groundwater drinking sources. The DCGL values in Table 6-11 may be adjusted as the project proceeds using the methods and limitations described in this section as long as the dose criteria are satisfied.

**Table 6-11a**  
**Containment Contaminated Material DCGL**

Basement Contaminated Concrete (gross beta dpm/100 cm <sup>2</sup> ):	18,000
Special Area Contaminated Concrete (gross beta dpm/100 cm <sup>2</sup> ):	9,500
Basement Activated Concrete - Released to Basement (pCi):	4.88E+08
Surface Soil (Cs-137 pCi/g):	2.39
Deep Soil (Cs-137 pCi/g):	2.39
BOP Embedded Piping [Limit: 100K], (gross beta dpm/100 cm <sup>2</sup> ):	100,000
Spray Building Pump Piping [Limit: 800K], (gross beta dpm/100 cm <sup>2</sup> ):	800,000
Ground Water (H-3, pCi/L):	6,812
Surface Water (H-3, pCi/L):	960
Buried Piping, Conduit and Cable, (gross beta dpm/100 cm <sup>2</sup> ):	9,800

<b>Containment Contaminated Material Annual Dose</b>			
<b>Material</b>	<b>Drinking Water (mrem/y)</b>	<b>Direct, Inhalation &amp; Ingestion (mrem/y)</b>	<b>Total Annual Dose (mrem/y)</b>
Contaminated Concrete	7.32E-02	8.53E-03	8.15E-02
Activated Concrete	1.36E-02	3.30E-02	4.66E-02
Surface Soil	0.00E+00	5.63E+00	5.63E+00
Deep Soil	5.33E-02	1.98E+00	2.04E+00
BOP Embedded Piping	4.59E-02	5.24E-03	5.11E-02
Spray Building Pump Embedded Piping	7.60E-02	8.68E-03	8.47E-02
Ground Water	2.08E-01	0.00E+00	2.08E-01
Surface Water	2.94E-02	1.27E-03	3.06E-02
Buried Piping, Conduit & Cable	6.33E-04	1.89E-03	2.52E-03
<b>Total</b>	<b>0.48 mrem/y</b>	<b>6.79 mrem/y</b>	<b>8.17 mrem/y</b>

**Table 6-11b**  
**Non-Containment Contaminated Material DCGL**

Basement Contaminated Concrete (gross beta dpm/100 cm <sup>2</sup> ):	18,000
Special Area Contaminated Concrete (gross beta dpm/100 cm <sup>2</sup> ):	9,500
Basement Activated Concrete - Released to Basement (pCi):	0.00
Surface Soil (Cs-137 pCi/g):	2.39
Deep Soil (Cs-137 pCi/g):	2.39
BOP Embedded Piping [Limit: 100K], (gross beta dpm/100 cm <sup>2</sup> ):	100,000
Spray Building Pump Piping [Limit: 800K], (gross beta dpm/100 cm <sup>2</sup> ):	800,000
Ground Water (H-3, pCi/L):	6,812
Surface Water (H-3, pCi/L):	960
Buried Piping, Conduit and Cable, (gross beta dpm/100 cm <sup>2</sup> ):	9,800

**Non-Containment Contaminated Material Annual Dose**

Material	Drinking Water (mrem/y)	Direct, Inhalation & Ingestion (mrem/y)	Total Annual Dose (mrem/y)
Contaminated Concrete	2.70E-01	3.08E-02	3.01E-01
Activated Concrete	0.00E+00	0.00E+00	0.00E+00
Surface Soil	0.00E+00	5.63E+00	5.63E+00
Deep Soil	5.33E-02	1.98E+00	2.04E+00
BOP Embedded Piping	4.59E-02	5.24E-03	5.11E-02
Spray Building Pump Embedded Piping	7.60E-02	8.68E-03	8.47E-02
Ground Water	2.08E-01	0.00E+00	2.08E-01
Surface Water	2.94E-02	1.27E-03	3.06E-02
Buried Piping, Conduit & Cable	6.33E-04	1.89E-03	2.52E-03
Total	0.66 mrem/y	6.78 mrem/y	8.34 mrem/y

The dose summation method is a conservative screening approach. For example, the environmental pathway analysis for deep soil indicated that a low concentration of tritium would reach groundwater three years after the site is released for unrestricted use. The location of the deep soil and corresponding groundwater contamination are obviously different from the location of building basements where the hypothetical resident farmer well was placed. In addition, the peak time for H-3 water concentration from deep soil is different from the peak time for the basement water concentration. Nonetheless, consistent with a screening approach, the peak H-3 concentration in groundwater from deep soil is fully added to the peak basement water concentration and the sum is used in the dose assessment. There was no reduction in concentration due to the differences in peak dose time or dilution through groundwater transport. A more realistic and less conservative environmental pathway analysis would consider these effects.

The Maine Yankee commitment to a conservative screening approach is also seen in the methods for adding the dose contributions from embedded piping, activated concrete/rebar, and contaminated surfaces in the building basements, as well the other contaminated materials. It is important to recognize that the conservative results from the dose summation are in addition to the conservatism already built into the unitized dose factor calculations for the individual contaminated materials.

Soil areas outside of the RA boundary will not require consideration of dose from any other materials. The area of the RA is approximately 10,000 m<sup>2</sup>, which represents the size of the resident farmer survey unit and contains the other contaminated materials considered (Refer to Section 5, Figure 5-2).<sup>2</sup> The other contaminated materials have essentially no effect outside of the RA and the dose is assumed to result from the contaminated soil only. In this case, the DCGLs will be based on the NUREG-1727 screening values corrected to represent 10 mrem/y. The soil radionuclide mixture applied to areas outside the RA boundary are assumed to be the same as the mixture listed in Table 2-11. The DCGL for areas outside the RA is 4.2 pCi/g. This DCGL can be calculated most directly by the ratio to the 2.39 pCi/g Cs-137 DCGL provided in LTP Table 6-11, recognizing that the dose from 2.39 pCi/g is 5.63 mrem/yr. This calculation is provided below:

$$4.2 \text{ pCi/g} = (2.39 \text{ pCi/g}) \frac{(10.00 \text{ mrem/yr})}{(5.63 \text{ mrem/yr})}$$

#### 6.7.1 Conceptual Model for Summing Contaminated Material Dose

The conceptual model for summing doses to the resident farmer essentially combines the dose from surface soil and deep soil with the dose from water derived from a well drilled directly into the worst case building basement. The well water is used for irrigation and drinking.

The source term for the well water concentrations includes contributions from basement contamination, activated concrete/rebar, and embedded piping. The model assumes that the residual contamination in all three materials is instantaneously released and mixed with water that has infiltrated the building basement.

The instantaneous release of all contamination is conservative for several reasons. Concrete contamination will be released at a rate associated with the diffusion coefficient for the various radionuclides. Activated concrete/rebar will actually be

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<sup>2</sup> The Figure 5-2 Class 1 Area represents the size of the Resident Farmer's farm and therefore, consists of that land area to which the Dose Summation Table 6-11 applies. While operational considerations may result in modifications to the RA boundary, the extent of land area to which Table 6-11 applies should not change.

released to the water at a relatively slow rate more closely linked to physical dissolution of concrete, which is expected to be very slow. For embedded piping, the actual contamination release rate is expected to be close to zero because any open pipe end that could be a point of release into a basement will be sealed. Another conservatism is the assumption that all of these sources are mixed in the same worst case 2460 m<sup>3</sup> of basement volume. In actuality, the various sources are in different areas and different buildings. Finally, the source term contributions from groundwater, surface water, and deep soil were added directly to the basement well concentrations without consideration of transport or dilution.

#### 6.7.2 Method and Calculations for Summing Contaminated Material Dose

The primary inputs to the dose summation are the unitized dose factor calculations developed for each contaminated material. The unitized dose spreadsheets were used for the dose calculations without modification. However, the input concentrations and inventories required modification to represent the selected DCGLs as opposed to unit concentrations. The additional calculations required to convert the DCGL values into radionuclide concentrations and inventories are described in the sections below.

To perform the summation and to provide a method to efficiently adjust the DCGLs for various materials, each of the individual material unitized dose spreadsheets was copied and linked in a single spreadsheet entitled DCGL/Total Dose. The spreadsheet output for the DCGL dose calculation for each material is provided in Attachment 6-13. These spreadsheets provide the calculations for the dose values reported in Table 6-11.

#### Contaminated Basement Surfaces

The DCGL for contaminated concrete is expressed as dpm/100 cm<sup>2</sup> detectable gross beta. This form was required because the final survey will be performed using gross beta measurements. The primary criteria for selecting the gross beta DCGL for basement surfaces was to ensure that the total dose, from all contaminated materials, was less than the 10/4 mrem/yr dose limit. There were two secondary criteria applied to the selection of the DCGL; 1) the DCGL would result in calculated basement fill concentrations below the surface soil DCGL, and 2) the DCGL was less than the NRC surface screening values from NUREG-1727, Table C2.2 (see Attachment 6-18).

To calculate the dose from a given gross beta DCGL, the gross beta concentration is converted to individual radionuclide concentrations based on their respective fractions in the radionuclide mixture. The individual concentrations are then input to the dose calculation spreadsheet for contaminated basement concrete.



Characterization data indicated that the radionuclide mixtures for “special areas” differs from the other the basement surfaces (see Table 2-8). Therefore, a separate mixture is applied to the dose assessment for the “special areas”, resulting in a different DCGL for the “special areas”. The DCGL selected for the “special areas” resulted in a lower dose than that calculated for the rest of the basement surfaces (see Attachment 6-13). Therefore, the total dose shown in Table 6-11 is based on the higher dose calculated for the general radionuclide mixture and DCGL, not the “special areas” mixture.

The individual radionuclide concentrations are calculated as follows:

Convert the detectable gross beta concentration to total radionuclide concentration:

$$\text{Total dpm/100 cm}^2 = (\text{gross beta dpm/100 cm}^2) / (\sum \text{gross beta radionuclide fractions}) \quad (15)$$

Where: Total dpm/100 cm<sup>2</sup> is the summation of activity from all radionuclides  
Gross beta is the detectable gross beta concentration  
 $\sum$  gross beta radionuclide fractions is the sum of the fractions of each radionuclide in the Maine Yankee mixture with detectable beta

Calculate each individual radionuclide concentration as follows:

$$C_R \text{ dpm/100 cm}^2 = (NF_R)(\text{Total dpm/100 cm}^2) \quad (16)$$

Where:  $C_R$  is the concentration of a given radionuclide  
 $NF_R$  is the nuclide fraction of a given radionuclide

### Surface Soil

The DCGL for surface soil is expressed in pCi/g Cs-137. The surface soil dose is calculated by first determining the individual radionuclide concentrations by ratio to Cs-137 using the relative fractions in the Maine Yankee mixture and then entering the individual concentrations into the “inventory” column in the dose calculation spreadsheet for surface soil.

During final survey, and in the final site dose assessment, the non-gamma emitting radionuclides (HTD nuclides) will be accounted for using Cs-137 as a surrogate as described in Equation 17 (from NUREG-1505, Page 11-2, Equation 11-4). The contribution from soil HTD radionuclides will be calculated using the radionuclide fractions listed in Table 2-11. Cs-137 was selected as the surrogate since it is the predominant radionuclide in soil (i.e., 89%) and since many of the soil samples

will not result in positively detected Co-60. As seen of page 5 of Attachment 6-13, the dose contribution from the HTD radionuclides in soil (Ni-63 and H-3) is less than 1% of the Cs-137 dose. Therefore, the effect of the surrogate calculation on the Cs-137 DCGL<sub>w</sub> value will be minimal.

To calculate the surrogate Cs-137 DCGL, the following equation is used:

$$CS-137_s = \frac{1}{\frac{1}{D_1} + \frac{R_2}{D_2} + \frac{R_3}{D_3} + \dots + \frac{R_n}{D_n}} \quad (17)$$

Where: Cs-137<sub>s</sub> is the surrogate Cs-137 DCGL<sub>w</sub>;

D<sub>1</sub> is the DCGL for Cs-137;

R<sub>n</sub> is the ratio of the HTD radionuclide mixture fraction to the Cs-137 mixture fraction; and

D<sub>n</sub> is the DCGL<sub>w</sub> of the HTD radionuclide corresponding to 10 mrem/yr. The DCGL's are calculated by inverting the Unitized Dose Factors Listed in the LTP, Table 6-7, and multiplying by 10.

The unitized dose factors were used in the total dose and DCGL calculations. This allowed the dose contribution of each radionuclide to be calculated and reviewed to understand the relative significance of the nuclides in the mixture. The dose calculated from the Cs-137 concentration shown in Table 6-11 will be the same regardless of whether a "surrogate" Cs-137 DCGL<sub>w</sub> is used or the unitized dose factors for all radionuclides are used.

The Cs-137 to Co-60 ratio will vary in the final survey soil samples and this will be accounted for using a "unity rule" approach as described in NUREG-1505, Chapter 11.

Before applying the unity rule, the DCGLs, for areas inside the RA, will be adjusted to represent the Table 6-11 total surface soil dose, as opposed to 10 mrem/yr. As seen in Table 6-11, the dose from surface soil is limited because of the additional dose from the other contaminated materials on the site. The unity rule calculation will limit the surface soil dose by multiplying the Cs-137<sub>s</sub> and Co-60 DCGL's corresponding to 10 mrem/yr by a factor equal to the Table 6-11 total surface soil dose value divided by 10 mrem/yr. If the dose contribution from surface soil changes in the future, the multiplication factor will change accordingly.

In order to demonstrate compliance with the surface soil DCGL, the gamma spectroscopy results for each soil sample will be converted to a unity rule equivalent using the Table 6-11 surface soil DCGL's in the following equation. After this conversion, the DCGL becomes a unitless value of 1.0 that is equivalent to the total surface soil dose shown in Table 6-11. If the dose contribution from surface soil changes in the future, the dose corresponding to a unity rule equivalent of 1.0 will change accordingly. The unity rule equivalent is calculated per the following equation:

$$\text{Unity Rule Equivalent} \leq 1 = \frac{\text{Cs-137}}{\text{DCGL}_{(\text{Cs-137}_s)}} + \frac{\text{Co-60}}{\text{DCGL}_{(\text{Co-60}_A)}} + \dots + \frac{R_N}{\text{DCGL}_{(N_A)}}$$

Where: Cs-137 and Co-60 are the gamma spec results,

$\text{DCGL}_{(\text{Cs-137}_s)}$  is the surrogate Cs-137<sub>s</sub> DCGL,

adjusted to represent the Table 6-11 total surface soil dose, as applicable (inside RA)

$\text{DCGL}_{(\text{Co-60}_A)}$  is the Co-60 DCGL adjusted to

represent the Table 6-11 total surface soil dose, as applicable (inside RA)

$R_N$  is any other identified gamma emitting radionuclides, and

$\text{DCGL}_{(N_A)}$  is the adjusted DCGL for radionuclide N.

Absent sample-specific information from the final survey, using the radionuclide mixture fractions to represent the final Cs-137/Co-60 ratios is the best method available to estimate dose and determine target soil concentrations for remediation planning.

#### Activated Concrete/Rebar

The DCGL for activated concrete/rebar is in units of pCi total activity at the wall and floor surfaces. Total activity includes all radionuclides in the Maine Yankee mixture.

### Deep Soil

The DCGL for deep soil, as for surface soil, is expressed in pCi/g Cs-137. The deep soil dose is calculated by first determining the individual radionuclide concentrations by ratio to Cs-137 using the relative fractions in the Maine Yankee surface soil mixture and then entering the individual concentrations into the "inventory" column in the dose calculation spreadsheet for deep soil. The surface soil radionuclide mixture is assumed to be representative of the deep soil mixture.

The issues related to compliance using final survey results for gamma emitters and the use of Cs-137 as a surrogate for the HTD radionuclides that were described for surface soil also apply to deep soil.

### Groundwater

The existing groundwater concentrations are entered directly into the DCGL/Total Dose spreadsheet. This allows the dose from current groundwater contamination to be accounted for. The entered concentration is not intended to be a DCGL. If Maine Yankee's estimate of existing groundwater concentration changes, the value(s) input to the final dose calculation for compliance with the 10/4 dose criteria will use the most applicable concentrations.

### Surface Water

The maximum concentration identified was used in the dose assessment. As with the groundwater concentration, the entered concentration is not a DCGL. If new sample data, if collected, indicates higher concentrations in site surface water, the new data will be used in the final dose assessment to demonstrate compliance with the 10/4 dose criteria.

### Buried Piping

The buried piping DCGL is expressed as dpm/100 cm<sup>2</sup> gross beta. The DCGL/Total Dose spreadsheet converts gross beta concentration to individual radionuclide concentrations analogous to contaminated basement surfaces. The resulting concentrations are entered in the dpm/100 cm<sup>2</sup> inventory column in the dose calculation spreadsheet.

### Embedded Piping

There is no embedded piping associated with the ISFSI or the adjacent area. The only areas that remain within the control of the 10 CFR 50 license. The embedded piping planned to remain after decommissioning of the Maine Yankee Nuclear Plant had a total internal surface area of 154.3 m<sup>2</sup>.

Maine Yankee evaluated the contamination potential of the embedded piping in the Containment, PAB, and Fuel building. Two different DCGL's were used for embedded piping. The DCGL for the spray pump piping was 800,000 dpm/100 cm<sup>2</sup> and the DCGL for the rest of the embedded piping in the Spray Building, Containment, PAB, and Fuel buildings was 100,000 dpm/100 cm<sup>2</sup>.

The inventory for the dose assessment was calculated assuming that the spray pump piping (26.5 m<sup>2</sup>) is contaminated at 800,000 dpm/100 cm<sup>2</sup> and that the remaining embedded piping (127.8 m<sup>2</sup>) is contaminated at 100,000 dpm/100 cm<sup>2</sup>. The entire inventory of embedded piping from all buildings was summed and assumed to be instantaneously released. The dose under these assumptions was calculated to be 0.136 mrem/yr.

The assumption of instantaneous release is conservative since the spray pump embedded piping will be filled with cement grout.

## 6.8 Area Factors

### 6.8.1 Basement Contamination

The basement contamination conceptual model described in Section 6.6.1 was based on a worst case surface area of 4182 m<sup>2</sup>. The model assumes uniform mixing within a 0.6 m layer of fill in direct contact with the 4182 m<sup>2</sup> surface area. The conceptual model assumes that the activity released from the wall is mixed with the 738 m<sup>3</sup> volume of water contained in the 0.6 m fill layer, but does not require the contamination to be uniformly distributed over the entire 4182 m<sup>2</sup> surface area. The model source term is the total inventory over the surface and is not dependent on the distribution of the contamination on the surface. Therefore, consistent with the conceptual model, the area factor could be a simple linear relationship between total activity and area. The area factor formula would then be described using the following equation:

$$AF = 4182 \text{ m}^2 / (\text{elevated area}) \quad (18)$$

where: AF is the area factor  
(elevated area) is the size of the area exceeding the DCGL<sub>w</sub>

Maine Yankee evaluated this potential approach and believes that it is consistent with NUREG-1575 and NUREG-1727 guidance which acknowledges that the area factors should be based on the dose model used to calculate the DCGL. However, it appears that substantially better remediation performance can be achieved than is reflected in Equation (18) and that leaving elevated areas at the levels allowed by the equation is not sufficiently conservative. Accordingly, the area factors for contaminated basement concrete will be calculated using Equation (19), which represents a considerably more conservative approach. The area factor used in the unity rule for contaminated basement concrete will be calculated using Equation (20) which ensures that the number of elevated areas in a survey unit are restricted to limit the inventory of activity allowed in a survey unit and maintain compliance with the release criteria.

$$AF = 50 \text{ m}^2 / (\text{elevated area}) \quad (19)$$

$$AF_{\text{unity rule}} = (\text{survey unit}) / (\text{elevated area}) \quad (20)$$

where: AF is the area factor  
(elevated area) is the size of the area exceeding the  $DCGL_w$   
(survey unit) is the size of the survey unit

The 50 m<sup>2</sup> area was selected after qualitative consideration of the potential residual contamination that could remain in elevated areas after a comprehensive remediation effort. Areas greater than 50 m<sup>2</sup> are required to be at or below the  $DCGL_w$ . Area factors can apply to elevated areas on any surface, but are expected to be applied primarily to contamination in cracks and crevices, or other geometries, that are not efficiently remediated. It is not expected that a large number of elevated areas will remain. The number of elevated areas allowed to remain is limited by the formula presented in Section 5.6.3. The survey unit size is determined in accordance with Section 5.3.1.a.

#### 6.8.2 Surface Soil and Deep Soil Area Factors

The NRC screening values were used to calculate the surface soil DCGLs. This approach does not provide a direct method of linking the area factor calculation to the dose model. The surface soil area factors were determined based on the change in direct radiation as a function of area. The relative exposure was determined using Microshield. The output reports are provided in Attachment 6-14.

Using direct radiation only is a conservative approach since area factors based on the ingestion and inhalation dose pathways increase at a faster rate than those based on the direct radiation pathway. This is evident from inspection of Table 5.6 in NUREG-1575 which shows, for example, the higher area factors for Am-241 as

compared to Cs-137 and Co-60. The area factors for surface and deep soil are listed in Table 6-12.

<b>Table 6-12</b> <b>Area Factors (AF) for Surface Soil and Deep Soil</b> <b>Survey Unit = 10,000 m<sup>2</sup></b>												
Area m <sup>2</sup>	1	2	4	6	8	16	25	50	100	500	1,000	10,000
Cs-137 (AF)	11.9	6.7	4.1	3.2	2.8	2.0	1.7	1.5	1.3	1.2	1.1	1.0
Co-60 (AF)	12.7	7.2	4.4	3.1	2.9	2.1	1.8	1.5	1.2	1.2	1.1	1.0
MY Mix (AF)*	12.0	6.8	4.1	3.2	2.8	2.0	1.8	1.5	1.3	1.2	1.1	1.0

\* Where MY mix is the surface and deep soil radionuclide mixture.

### 6.8.3 Embedded Piping Area Factors

Since the dose model for embedded piping is the same as the basement fill model, the same area factor equation would apply.

$$AF = \frac{50m^2}{elevated\ area}$$

An evaluation of contamination potential and remediation effectiveness in embedded piping concluded that area factors can be limited to 2.0. Area factors larger than 2.0 can readily be justified on a dose basis using the above equation. However, a conservative application of ALARA was applied to limit the embedded piping area factor to 2.0

The number of elevated areas in embedded piping will be limited to ensure that the source term inventory (and annual dose) relative to the selected DCGL(s) is not exceeded.

### 6.8.4 Buried Piping Area Factors

Buried piping contributes less than one-tenth of one percent of the total dose to the resident farmer. The volume of piping expected to remain on site is 142.0 m<sup>3</sup>. The radioactive contaminants associated with buried pipe are considered to be excavated to the soil surface uniformly mixed in the top 0.15 m of soil. Under these conditions area factors for soil would apply.

The following equation calculates an area factor that is ALARA and conserves the survey unit total inventory. As a measure of conservatism, a limit of 10 is placed

on area factors for buried piping. The  $DCGL_{EMC}$  (the DCGL used for the elevated measurement criteria) is calculated using the same equation.

$$Area\ Factor = \frac{Buried\ Piping\ Survey\ Unit\ Size(m^2)}{Buried\ Piping\ Elevated\ Area(m^2)}$$

For example, a 20 m<sup>2</sup> survey unit containing a 1.0 m<sup>2</sup> elevated area and using the DCGL of 9.50E+03 dpm/100 cm<sup>2</sup> would result in an area factor (AF) of 20:

$$Area\ Factor = 20 = \frac{20m^2}{1.0m^2}$$

The AF would be limited to 10 as stated above so the allowable activity in the elevated area would be 9.50E+04 dpm/100 cm<sup>2</sup>. The  $DCGL_{EMC}$  calculated by the equation would be 20 times the DCGL or 1.90E+05 dpm/100 cm<sup>2</sup>.

If the maximum concentration of the elevated area (i.e., 9.50E+04 dpm/100 cm<sup>2</sup>) were the only activity in the survey unit, the unity rule application would be as follows:

$$Unity\ Rule = \frac{9.50E + 04 \frac{dpm}{100cm^2}}{1.90E + 05 \frac{dpm}{100cm^2}} = 0.5\ which\ is < 1.0$$

#### 6.8.5 Activated Concrete/Rebar Area Factors

The activated concrete/rebar conceptual model is conservatively treated in a similar manner as the basement contamination model. Activated concrete includes the source term in the entire volume of activated concrete (surface and subsurface). Unlike the basement fill model however, the activated radionuclide inventory is realistically released. Since the dose models are similar, the area factor for the Basement Fill Model (Section 6.8.1, equation 19 or 20 of the LTP) will be used for activated concrete.

### 6.9 Standing Building Dose Assessment and DCGL Determination

#### 6.9.1 Dose Assessment Method

This dose assessment applies to the occupancy of a standing building and does not apply to the filled building basement. Current plans call for only one building to



remain standing after decommissioning, i.e., the switchyard relay house. The NRC screening values from NUREG-1727, Table C2.2 were used for building occupancy dose assessment and DCGL determination. The screening values were adjusted to correspond to 10 mrem/y.

NUREG-1727, NMSS Decommissioning Standard Review Plan, Appendix C, describes the justification necessary to allow direct use of these screening values. When using the screening approach licensees need to demonstrate that the particular site conditions (e.g., physical and source term conditions) are compatible and consistent with the DandD model assumptions.

The following site conditions are specified for use of the Standing Building screening values:

1. The contamination on building surfaces (e.g., walls, floors, ceilings) should be surficial and non-volumetric (e.e., less than 0.4 in (10 mm)).
2. Contamination on surfaces is mostly fixed (not loose), with the fraction of loose contamination not to exceed 10 percent of the total surface activity.
3. The screening criteria are not applied to surfaces such as buried structures (e.g., drainage or sewer pipes) or mobile equipment within the building; such structures and buried surfaces will be treated on a case-by-case basis.

The above conditions are satisfied for the Maine Yankee site.

#### 6.9.2 Standing Building DCGLs

The standing building DCGL was calculated as shown in Table 6-13. The DCGLs were calculated using Equation 4-4 in NUREG-1727 as adjusted for gross beta by multiplying the results by the gross beta radionuclide fraction in the mixture. The DCGL was expressed as gross beta since the final survey of a standing building, if necessary, will be performed using gross beta measurements.

<b>Table 6-13</b> <b>Gross Beta DCGL For Standing Buildings</b> <b>(Not Applicable to Basements to be Filled)</b>				
<b>Nuclide</b>	<b>Nuclide Fraction (nf)</b>	<b>Screening Level dpm/100 cm<sup>2</sup></b>	<b>Beta Fraction</b>	<b>nf/Screening Level</b>
H-3	2.36E-02	4.96E+07		4.75E-10
Fe-55	4.81E-03	1.80E+06		2.67E-09
Co-57	3.06E-04	8.44E+04		3.63E-09
Co-60	5.84E-02	2.82E+03	5.84E-02	2.07E-05
Ni-63	3.55E-01	7.28E+05		4.88E-07
Sr-90	2.80E-03	3.48E+03	2.80E-03	8.04E-07
Cs-134	4.55E-03	5.08E+03	4.55E-03	8.95E-07
Cs-137	5.50E-01	1.12E+04	5.50E-01	4.91E-05
		Sum	6.16E-01	7.20E-5
				DCGL 8.554E+03 β dpm/100 cm <sup>2</sup> (10 mrem/y)

### 6.9.3 Standing Building Area Factors

As discussed above for soil, using the NRC screening values for DCGL determination does not allow for direct determination of area factors. Consistent with the method used for soil, Microshield runs were used to generate the area factors by starting with an area of 100 m<sup>2</sup> and calculating the relative exposure rate as the area is decreased. The ratio of the 100 m<sup>2</sup> exposure rate to the respective smaller area exposure rate represents the area factor for the given elevated area size. Attachment 6-15 contains the Microshield runs and Table 6-14 provides the resulting area factors

<b>Table 6-14</b> <b>Area Factors (AF) for Standing Buildings</b> <b>(Does Not Apply to Building Basements To Be Filled)</b> <b>Survey Unit Size = 100 m<sup>2</sup></b>									
Area m <sup>2</sup>	0.5	1	2	4	8	16	25	50	100
<b>Cs-137 (AF)</b>	23.5	12.6	7.1	4.3	2.8	1.9	1.6	1.2	1.0
<b>Co-60 (AF)</b>	23.5	12.6	7.1	4.3	2.8	1.9	1.6	1.2	1.0
<b>MY Mix (AF)</b>	23.5	12.6	7.1	4.3	2.8	1.9	1.6	1.2	1.0

\* Where MY mix is the Contaminated Concrete radionuclide mixture.

## 6.10 References

- 6.10.1 Baes, C.F., R.D. Sharp, A.L. Sjorren, and R.W. Shor, 1984. "A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture," ORNL-5786, Oak Ridge National Laboratory.
- 6.10.2 U.S. Environmental Protection Agency, 1988. "External Exposure to Radionuclides in Air Water and Soil, Federal Guidance Report No. 11," EPA 520/1-88-020, U. S. EPA Office of Radiation and Indoor Air.
- 6.10.3 Krupka, K.M., and R.J. Serne, 1998. "Effects on Radionuclide Concentrations by Cement/Ground-Water Interactions in Support of Performance Assessment of Low-Level Radioactive Waste Disposal Facilities," NUREG/CR-6377, PNNL-14408.
- 6.10.4 Onishi, Y., R.J. Serne, R.M. Arnold, C.E. Cowan, and F.L. Thompson, 1981. "Critical Review: Radionuclide Transport, Sediment Transport, and Water Quality Mathematical Modeling; and Radionuclide Adsorption/Desorption Mechanisms," NUREG/CR-1322, PNL-2901.
- 6.10.5 Sheppard, M.I. and D.H. Thibault, 1990. "Default Soil Solid/Liquid Partition Coefficients."
- 6.10.6 Maine Yankee Engineering Calculation, Diffuser and Forebay Dose Assessment, EC-041-01 (MY), Revision 0.

- 6.10.7 Maine Yankee letter to NRC (MN-03-049), dated September 11, 2003, Proposed Change: Revised Activated Concrete DCGL and More Realistic Activated Concrete Dose Modeling - License Condition 2.B.(10), License Termination
- 6.10.8 NRC letter to Maine Yankee, dated February 18, 2004, Issuance of Amendment No. 170 to Facility Operating License No. DPR-36 - Maine Yankee Atomic Power Station (TAC No. M8000).

**MYAPC License Termination Plan  
Revision 3  
October 15, 2002**

**Attachment 6-1  
Fill Direct Dose Microshield Output**

**Basement Fill Direct Dose  
Unitized Values**

This attachment provides the Microshield outputs for direct dose factors for basement fill. The area size is 10,000 m<sup>2</sup> by 5.8 m deep. Fill density is 1.5 g/cm<sup>3</sup>. The dose point is 1 meter above the soil surface. The shielded data assume 1 m of clean soil has been placed on top of the basement fill material. The dose factor assumes 964 hours exposure time per year.

Page : 1  
DOS File : SOILFL.MS5  
Run Date: March 15, 2001  
Run Time: 10:45:17 AM  
Duration : 00:00:10

File Ref: \_\_\_\_\_  
Date: \_\_\_\_\_  
By: \_\_\_\_\_  
Checked: \_\_\_\_\_

Case Title: Soil Fill  
Description: Using the RESRAD land area approx.10000 m2  
Geometry: 13 - Rectangular Volume



	Source Dimensions	
Length	580.0 cm	19 ft 0.3 in
Width	1.0e+4 cm	328 ft 1.0 in
Height	1.0e+4 cm	328 ft 1.0 in

	Dose Points		
	X	Y	Z
# 1	780 cm	5000 cm	5000 cm
	25 ft 7.1 in	164 ft 0.5 in	164 ft 0.5 in

Shields			
Shield Name	Dimension	Material	Density
Source	5.80e+10 cm³	SiO2	1.5
Shield 1	100.0 cm	SiO2	1.5
Air Gap		Air	0.00122

Source Input				
Grouping Method : Actual Photon Energies				
Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Ba-137m	8.7000e-002	3.2190e+009	1.5000e-006	5.5500e-002
Cs-137	8.7000e-002	3.2190e+009	1.5000e-006	5.5500e-002

Buildup  
The material reference is : Source

Integration Parameters	
X Direction	10
Y Direction	20
Z Direction	20

Results

DOS File : SOILFL.MS5  
 Run Date: March 15, 2001  
 Run Time: 10:45:17 AM  
 Duration : 00:00:10

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.0318	6.664e+07	2.688e-67	7.288e-28	2.239e-69	6.071e-30
0.0322	1.230e+08	3.170e-65	1.403e-27	2.551e-67	1.129e-29
0.0364	4.474e+07	2.967e-50	8.637e-28	1.686e-52	4.907e-30
0.6616	2.896e+09	1.398e-07	7.706e-06	2.711e-10	1.494e-08
TOTALS:	3.131e+09	1.398e-07	7.706e-06	2.711e-10	1.494e-08



MicroShield v5.05 (5.05-00201)  
Maine Yankee  
Conversion of calculated exposure in air to dose  
FILE: C:\MS5\DATA\SOILFL.MS5  
Case Title: Soil Fill

Cs-137

This case was run on Thursday, March 15, 2001 at 10:45:17 AM  
Dose Point # 1 - (780,5000,5000) cm

<u>Results (Summed over energies)</u>	<u>Units</u>	<u>Without Buildup</u>	<u>With Buildup</u>
Photon Fluence Rate (flux)	Photons/cm <sup>2</sup> /sec	2.114e-007	1.165e-005
Photon Energy Fluence Rate	MeV/cm <sup>2</sup> /sec	1.398e-007	7.706e-006
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.711e-010	1.494e-008
Absorbed Dose Rate in Air	mGy/hr	2.367e-012	1.304e-010
"	mrad/hr	2.367e-010	1.304e-008
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.802e-012	1.544e-010
o Opposed	"	2.244e-012	1.236e-010
o Rotational	"	2.244e-012	1.236e-010
o Isotropic	"	1.984e-012	1.093e-010
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.978e-012	1.641e-010
o Opposed	"	2.829e-012	1.559e-010
o Rotational	"	2.829e-012	1.559e-010
o Isotropic	"	2.121e-012	1.169e-010
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.478e-012	1.365e-010
o Posterior/Anterior	"	2.187e-012	1.205e-010
o Lateral	"	1.622e-012	8.936e-011
o Rotational	"	1.954e-012	1.077e-010
o Isotropic	"	1.664e-012	9.168e-011

MicroShield v5.05 (5.05-00201)  
 Maine Yankee  
 Conversion of calculated exposure in air to dose  
 FILE: C:\MS5\DATA\SOILFL.MS5  
 Case Title: Soil Fill

Cs-134

This case was run on Thursday, March 15, 2001 at 10:47:42 AM  
 Dose Point # 1 - (780,5000,5000) cm

<u>Results (Summed over energies)</u>	<u>Units</u>	<u>Without Buildup</u>	<u>With Buildup</u>
Photon Fluence Rate (flux)	Photons/cm <sup>2</sup> /sec	1.411e-006	4.701e-005
Photon Energy Fluence Rate	MeV/cm <sup>2</sup> /sec	1.390e-006	4.050e-005
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.526e-009	7.528e-008
Absorbed Dose Rate in Air	mGy/hr	2.205e-011	6.572e-010
"	mrads/hr	2.205e-009	6.572e-008
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.539e-011	7.628e-010
o Opposed	"	2.134e-011	6.318e-010
o Rotational	"	2.134e-011	6.318e-010
o Isotropic	"	1.898e-011	5.604e-010
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.706e-011	8.132e-010
o Opposed	"	2.594e-011	7.774e-010
o Rotational	"	2.594e-011	7.774e-010
o Isotropic	"	2.019e-011	5.976e-010
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.273e-011	6.806e-010
o Posterior/Anterior	"	2.064e-011	6.127e-010
o Lateral	"	1.605e-011	4.694e-010
o Rotational	"	1.854e-011	5.493e-010
o Isotropic	"	1.618e-011	4.756e-010

MicroShield v5.05 (5.05-00201)  
 Maine Yankee  
 Conversion of calculated exposure in air to dose  
 FILE: C:\MS5\DATA\SOILFL.MS5  
 Case Title: Soil Fill

C-57

This case was run on Thursday, March 15, 2001 at 10:53:24 AM  
 Dose Point # 1 - (780,5000,5000) cm

<u>Results (Summed over energies)</u>	<u>Units</u>	<u>Without Buildup</u>	<u>With Buildup</u>
Photon Fluence Rate (flux)	Photons/cm <sup>2</sup> /sec	5.133e-010	2.688e-008
Photon Energy Fluence Rate	MeV/cm <sup>2</sup> /sec	3.520e-010	1.819e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	6.800e-013	3.515e-011
Absorbed Dose Rate in Air	mGy/hr	5.936e-015	3.068e-013
"	mrads/hr	5.936e-013	3.068e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	7.006e-015	3.624e-013
o Opposed	"	5.637e-015	2.913e-013
o Rotational	"	5.637e-015	2.913e-013
o Isotropic	"	4.984e-015	2.576e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	7.458e-015	3.857e-013
o Opposed	"	7.091e-015	3.666e-013
o Rotational	"	7.091e-015	3.666e-013
o Isotropic	"	5.330e-015	2.755e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	6.204e-015	3.209e-013
o Posterior/Anterior	"	5.492e-015	2.839e-013
o Lateral	"	4.091e-015	2.113e-013
o Rotational	"	4.909e-015	2.538e-013
o Isotropic	"	4.188e-015	2.164e-013

MicroShield v5.05 (5.05-00201)  
Maine Yankee  
Conversion of calculated exposure in air to dose  
FILE: C:\MS5\DATA\SOILFL.MS5  
Case Title: Soil Fill

*Co-60*

This case was run on Thursday, March 15, 2001 at 10:46:39 AM  
Dose Point # 1 - (780,5000,5000) cm

<u>Results (Summed over energies)</u>	<u>Units</u>	<u>Without Buildup</u>	<u>With Buildup</u>
Photon Fluence Rate (flux)	Photons/cm <sup>2</sup> /sec	1.904e-005	3.434e-004
Photon Energy Fluence Rate	MeV/cm <sup>2</sup> /sec	2.435e-005	4.366e-004
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	4.264e-008	7.655e-007
Absorbed Dose Rate in Air	mGy/hr	3.722e-010	6.683e-009
"	mrads/hr	3.722e-008	6.683e-007
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	4.224e-010	7.586e-009
o Opposed	"	3.641e-010	6.536e-009
o Rotational	"	3.641e-010	6.536e-009
o Isotropic	"	3.254e-010	5.839e-009
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	4.496e-010	8.075e-009
o Opposed	"	4.330e-010	7.776e-009
o Rotational	"	4.330e-010	7.776e-009
o Isotropic	"	3.446e-010	6.185e-009
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	3.804e-010	6.832e-009
o Posterior/Anterior	"	3.506e-010	6.295e-009
o Lateral	"	2.792e-010	5.008e-009
o Rotational	"	3.158e-010	5.668e-009
o Isotropic	"	2.796e-010	5.018e-009

Mn-54

MicroShield v5.05 (5.05-00201)  
Maine Yankee  
Conversion of calculated exposure in air to dose  
FILE: C:\MS5\DATA\SOILFL.MS5  
Case Title: Soil Fill

This case was run on Thursday, March 15, 2001 at 11:04:04 AM  
Dose Point # 1 - (780,5000,5000) cm

<u>Results (Summed over energies)</u>	<u>Units</u>	<u>Without Buildup</u>	<u>With Buildup</u>
Photon Fluence Rate (flux)	Photons/cm <sup>2</sup> /sec	9.506e-007	3.449e-005
Photon Energy Fluence Rate	MeV/cm <sup>2</sup> /sec	7.936e-007	2.879e-005
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.502e-009	5.448e-008
Absorbed Dose Rate in Air	mGy/hr	1.311e-011	4.756e-010
"	mrads/hr	1.311e-009	4.756e-008
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.523e-011	5.524e-010
o Opposed	"	1.257e-011	4.559e-010
o Rotational	"	1.257e-011	4.559e-010
o Isotropic	"	1.111e-011	4.030e-010
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.630e-011	5.914e-010
o Opposed	"	1.557e-011	5.647e-010
o Rotational	"	1.557e-011	5.647e-010
o Isotropic	"	1.189e-011	4.314e-010
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.358e-011	4.928e-010
o Posterior/Anterior	"	1.220e-011	4.426e-010
o Lateral	"	9.291e-012	3.370e-010
o Rotational	"	1.093e-011	3.963e-010
o Isotropic	"	9.419e-012	3.417e-010

56-125

MicroShield v5.05 (5.05-00201)  
 Maine Yankee  
 Conversion of calculated exposure in air to dose  
 FILE: C:\MS5\DATA\SOILFL.MS5  
 Case Title: Soil Fill

This case was run on Thursday, March 15, 2001 at 11:05:19 AM  
 Dose Point # 1 - (780,5000,5000) cm

<u>Results (Summed over energies)</u>	<u>Units</u>	<u>Without Buildup</u>	<u>With Buildup</u>
Photon Fluence Rate (flux)	Photons/cm <sup>2</sup> /sec	6.198e-008	4.227e-006
Photon Energy Fluence Rate	MeV/cm <sup>2</sup> /sec	3.724e-008	2.473e-006
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	7.255e-011	4.820e-009
Absorbed Dose Rate in Air	mGy/hr	6.333e-013	4.208e-011
"	mrads/hr	6.333e-011	4.208e-009
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	7.563e-013	5.038e-011
o Opposed	"	5.980e-013	3.969e-011
o Rotational	"	5.980e-013	3.969e-011
o Isotropic	"	5.288e-013	3.510e-011
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	8.007e-013	5.328e-011
o Opposed	"	7.588e-013	5.047e-011
o Rotational	"	7.588e-013	5.047e-011
o Isotropic	"	5.648e-013	3.749e-011
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	6.669e-013	4.439e-011
o Posterior/Anterior	"	5.848e-013	3.887e-011
o Lateral	"	4.291e-013	2.845e-011
o Rotational	"	5.220e-013	3.467e-011
o Isotropic	"	4.422e-013	2.935e-011

Pu-238

MicroShield v5.05 (5.05-00201)  
 Maine Yankee  
 Conversion of calculated exposure in air to dose  
 FILE: C:\MS5\DATA\SOILFL.MS5  
 Case Title: Soil Fill

This case was run on Thursday, March 15, 2001 at 11:09:58 AM  
 Dose Point # 1 - (780,5000,5000) cm

<u>Results (Summed over energies)</u>	<u>Units</u>	<u>Without Buildup</u>	<u>With Buildup</u>
Photon Fluence Rate (flux)	Photons/cm <sup>2</sup> /sec	5.584e-026	2.808e-024
Photon Energy Fluence Rate	MeV/cm <sup>2</sup> /sec	3.088e-027	1.553e-025
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	6.890e-030	3.465e-028
Absorbed Dose Rate in Air	mGy/hr	6.015e-032	3.025e-030
"	mrads/hr	6.015e-030	3.025e-028
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.034e-031	5.202e-030
o Opposed	"	5.340e-032	2.686e-030
o Rotational	"	5.051e-032	2.540e-030
o Isotropic	"	4.944e-032	2.486e-030
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.032e-031	5.188e-030
o Opposed	"	7.038e-032	3.540e-030
o Rotational	"	7.038e-032	3.540e-030
o Isotropic	"	5.229e-032	2.630e-030
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	7.884e-032	3.965e-030
o Posterior/Anterior	"	5.515e-032	2.774e-030
o Lateral	"	3.257e-032	1.638e-030
o Rotational	"	4.650e-032	2.338e-030
o Isotropic	"	3.783e-032	1.903e-030

Pu-239

MicroShield v5.05 (5.05-00201)  
 Maine Yankee  
 Conversion of calculated exposure in air to dose  
 FILE: C:\MS5\DATA\SOILFL.MS5  
 Case Title: Soil Fill

This case was run on Thursday, March 15, 2001 at 11:10:41 AM  
 Dose Point # 1 - (780,5000,5000) cm

<u>Results (Summed over energies)</u>	<u>Units</u>	<u>Without Buildup</u>	<u>With Buildup</u>
Photon Fluence Rate (flux)	Photons/cm <sup>2</sup> /sec	1.152e-016	4.535e-014
Photon Energy Fluence Rate	MeV/cm <sup>2</sup> /sec	1.301e-017	5.121e-015
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.013e-020	7.920e-018
Absorbed Dose Rate in Air	mGy/hr	1.757e-022	6.914e-020
"	mrad/hr	1.757e-020	6.914e-018
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.842e-022	1.118e-019
o Opposed	"	1.600e-022	6.294e-020
o Rotational	"	1.609e-022	6.331e-020
o Isotropic	"	1.535e-022	6.042e-020
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.830e-022	1.114e-019
o Opposed	"	2.263e-022	8.904e-020
o Rotational	"	2.263e-022	8.904e-020
o Isotropic	"	1.636e-022	6.439e-020
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.462e-022	9.688e-020
o Posterior/Anterior	"	1.947e-022	7.663e-020
o Lateral	"	1.205e-022	4.742e-020
o Rotational	"	1.662e-022	6.540e-020
o Isotropic	"	1.325e-022	5.216e-020



Pu-240

MicroShield v5.05 (5.05-00201)  
Maine Yankee  
Conversion of calculated exposure in air to dose  
FILE: C:\MS5\DATA\SOILFL.MS5

Case Title: Soil Fill

This case was run on Thursday, March 15, 2001 at 11:11:24 AM  
Dose Point # 1 - (780,5000,5000) cm

<u>Results (Summed over energies)</u>	<u>Units</u>	<u>Without Buildup</u>	<u>With Buildup</u>
Photon Fluence Rate (flux)	Photons/cm <sup>2</sup> /sec	1.825e-026	8.603e-025
Photon Energy Fluence Rate	MeV/cm <sup>2</sup> /sec	9.912e-028	4.674e-026
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.276e-030	1.073e-028
Absorbed Dose Rate in Air	mGy/hr	1.987e-032	9.369e-031
"	mrads/hr	1.987e-030	9.369e-029
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.395e-032	1.601e-030
o Opposed	"	1.750e-032	8.253e-031
o Rotational	"	1.654e-032	7.797e-031
o Isotropic	"	1.617e-032	7.623e-031
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.388e-032	1.598e-030
o Opposed	"	2.307e-032	1.088e-030
o Rotational	"	2.307e-032	1.088e-030
o Isotropic	"	1.715e-032	8.089e-031
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.566e-032	1.210e-030
o Posterior/Anterior	"	1.786e-032	8.420e-031
o Lateral	"	1.053e-032	4.966e-031
o Rotational	"	1.508e-032	7.112e-031
o Isotropic	"	1.226e-032	5.782e-031

MicroShield v5.05 (5.05-00201)  
Maine Yankee  
Conversion of calculated exposure in air to dose  
FILE: C:\MS5\DATA\SOILFL.MS5  
Case Title: Soil Fill

Am 241

This case was run on Thursday, March 15, 2001 at 10:52:18 AM  
Dose Point # 1 - (780,5000,5000) cm

<u>Results (Summed over energies)</u>	<u>Units</u>	<u>Without Buildup</u>	<u>With Buildup</u>
Photon Fluence Rate (flux)	Photons/cm <sup>2</sup> /sec	1.751e-020	1.852e-018
Photon Energy Fluence Rate	MeV/cm <sup>2</sup> /sec	1.177e-021	1.259e-019
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.084e-024	2.204e-022
Absorbed Dose Rate in Air	mGy/hr	1.819e-026	1.924e-024
"	mrads/hr	1.819e-024	1.924e-022
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.223e-026	3.412e-024
o Opposed	"	1.690e-026	1.791e-024
o Rotational	"	1.618e-026	1.716e-024
o Isotropic	"	1.603e-026	1.701e-024
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.196e-026	3.382e-024
o Opposed	"	2.259e-026	2.396e-024
o Rotational	"	2.259e-026	2.396e-024
o Isotropic	"	1.664e-026	1.764e-024
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.617e-026	2.780e-024
o Posterior/Anterior	"	1.925e-026	2.049e-024
o Lateral	"	1.162e-026	1.239e-024
o Rotational	"	1.622e-026	1.727e-024
o Isotropic	"	1.324e-026	1.410e-024

Cm-243

MicroShield v5.05 (5.05-00201)  
Maine Yankee  
Conversion of calculated exposure in air to dose  
FILE: C:\MS5\DATA\SOILFL.MS5  
Case Title: Soil Fill

This case was run on Thursday, March 15, 2001 at 10:55:04 AM  
Dose Point # 1 - (780,5000,5000) cm

<u>Results (Summed over energies)</u>	<u>Units</u>	<u>Without Buildup</u>	<u>With Buildup</u>
Photon Fluence Rate (flux)	Photons/cm <sup>2</sup> /sec	1.210e-010	3.335e-008
Photon Energy Fluence Rate	MeV/cm <sup>2</sup> /sec	3.258e-011	8.907e-009
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	6.086e-014	1.661e-011
Absorbed Dose Rate in Air	mGy/hr	5.313e-016	1.450e-013
"	mrads/hr	5.313e-014	1.450e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	7.061e-016	1.930e-013
o Opposed	"	4.852e-016	1.324e-013
o Rotational	"	4.853e-016	1.324e-013
o Isotropic	"	4.379e-016	1.195e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	7.177e-016	1.960e-013
o Opposed	"	6.628e-016	1.809e-013
o Rotational	"	6.628e-016	1.809e-013
o Isotropic	"	4.691e-016	1.281e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	6.090e-016	1.664e-013
o Posterior/Anterior	"	5.048e-016	1.379e-013
o Lateral	"	3.428e-016	9.360e-014
o Rotational	"	4.418e-016	1.207e-013
o Isotropic	"	3.665e-016	1.001e-013

**MicroShield v5.05 (5.05-00201)**  
**Maine Yankee**  
**Conversion of calculated exposure in air to dose**  
**FILE: C:\MS5\DATA\SOILFL.MS5**  
**Case Title: Soil Fill**

*Cm-244*

This case was run on Thursday, March 15, 2001 at 10:56:00 AM  
Dose Point # 1 - (780,5000,5000) cm

<u>Results (Summed over energies)</u>	<u>Units</u>	<u>Without Buildup</u>	<u>With Buildup</u>
Photon Fluence Rate (flux)	Photons/cm <sup>2</sup> /sec	2.011e-025	1.127e-023
Photon Energy Fluence Rate	MeV/cm <sup>2</sup> /sec	1.143e-026	6.409e-025
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.445e-029	1.370e-027
Absorbed Dose Rate in Air	mGy/hr	2.134e-031	1.196e-029
"	mrads/hr	2.134e-029	1.196e-027
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.703e-031	2.075e-029
o Opposed	"	1.916e-031	1.074e-029
o Rotational	"	1.816e-031	1.018e-029
o Isotropic	"	1.780e-031	9.979e-030
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.689e-031	2.067e-029
o Opposed	"	2.527e-031	1.416e-029
o Rotational	"	2.527e-031	1.416e-029
o Isotropic	"	1.874e-031	1.050e-029
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.857e-031	1.601e-029
o Posterior/Anterior	"	2.014e-031	1.129e-029
o Lateral	"	1.192e-031	6.680e-030
o Rotational	"	1.694e-031	9.496e-030
o Isotropic	"	1.381e-031	7.738e-030

EU-152

MicroShield v5.05 (5.05-00201)  
 Maine Yankee  
 Conversion of calculated exposure in air to dose  
 FILE: C:\MS5\DATA\SOILFL.MS5  
 Case Title: Soil Fill

This case was run on Thursday, March 15, 2001 at 10:58:51 AM  
 Dose Point # 1 - (780,5000,5000) cm

<u>Results (Summed over energies)</u>	<u>Units</u>	<u>Without Buildup</u>	<u>With Buildup</u>
Photon Fluence Rate (flux)	Photons/cm <sup>2</sup> /sec	6.572e-006	1.107e-004
Photon Energy Fluence Rate	MeV/cm <sup>2</sup> /sec	9.187e-006	1.467e-004
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.567e-008	2.528e-007
Absorbed Dose Rate in Air	mGy/hr	1.368e-010	2.207e-009
"	mrads/hr	1.368e-008	2.207e-007
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.550e-010	2.506e-009
o Opposed	"	1.347e-010	2.168e-009
o Rotational	"	1.347e-010	2.168e-009
o Isotropic	"	1.207e-010	1.940e-009
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.643e-010	2.659e-009
o Opposed	"	1.588e-010	2.567e-009
o Rotational	"	1.588e-010	2.567e-009
o Isotropic	"	1.272e-010	2.048e-009
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.397e-010	2.256e-009
o Posterior/Anterior	"	1.293e-010	2.084e-009
o Lateral	"	1.041e-010	1.669e-009
o Rotational	"	1.167e-010	1.879e-009
o Isotropic	"	1.039e-010	1.667e-009

Eu-154

MicroShield v5.05 (5.05-00201)  
Maine Yankee  
Conversion of calculated exposure in air to dose  
FILE: C:\MS5\DATA\SOILFL.MS5  
Case Title: Soil Fill

This case was run on Thursday, March 15, 2001 at 10:59:56 AM  
Dose Point # 1 - (780,5000,5000) cm

<u>Results (Summed over energies)</u>	<u>Units</u>	<u>Without Buildup</u>	<u>With Buildup</u>
Photon Fluence Rate (flux)	Photons/cm <sup>2</sup> /sec	1.002e-005	1.593e-004
Photon Energy Fluence Rate	MeV/cm <sup>2</sup> /sec	1.440e-005	2.195e-004
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.442e-008	3.749e-007
Absorbed Dose Rate in Air	mGy/hr	2.132e-010	3.273e-009
"	mrads/hr	2.132e-008	3.273e-007
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.414e-010	3.712e-009
o Opposed	"	2.103e-010	3.223e-009
o Rotational	"	2.103e-010	3.223e-009
o Isotropic	"	1.886e-010	2.887e-009
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.556e-010	3.934e-009
o Opposed	"	2.473e-010	3.802e-009
o Rotational	"	2.473e-010	3.802e-009
o Isotropic	"	1.985e-010	3.043e-009
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.176e-010	3.343e-009
o Posterior/Anterior	"	2.018e-010	3.094e-009
o Lateral	"	1.629e-010	2.488e-009
o Rotational	"	1.822e-010	2.792e-009
o Isotropic	"	1.624e-010	2.483e-009

**MYAPC License Termination Plan**  
**Revision 3**  
**October 15, 2002**

**Attachment 6-2**  
**BNL Kd Report for Fill**

**Backfill Materials for the Maine Yankee Site**  
**Bulk Density and Partition Coefficients for Co, Cs, Sr, and Ni**

**Revised October 17, 2001**

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**Partition Coefficients**

**Method**

To determine the partition coefficients ( $K_D$ ) of Co, Cs, Sr, and Ni, four materials from the Maine Yankee site were exposed to low activity tracers of  $^{57}\text{Co}$ ,  $^{137}\text{Cs}$ ,  $^{85}\text{Sr}$ , and  $^{63}\text{Ni}$ . The tracers each were prepared by initially diluting them from the "as received" concentrations of 100 Ci/mL to 4.76 Ci/mL. Two mL of each of the first three tracers ( $^{57}\text{Co}$ ,  $^{85}\text{Sr}$ , and  $^{137}\text{Cs}$ ) were mixed together and the pH was adjusted to 6.0, giving a final concentration of each tracer in the mixture of 0.476 Ci/mL. Stock solutions of  $^{63}\text{Ni}$  were prepared separately because this pure beta-emitter had to be counted in a liquid scintillation counter.

**$^{57}\text{Co}$ ,  $^{85}\text{Sr}$ , and  $^{137}\text{Cs}$**

For each sample of material to be tested, the contact solution was prepared by weighing out 44 g of distilled water into a plastic bottle and adding 1.0 mL of mixed tracer solution. The contact solution had a concentration of each tracer of 0.01 Ci/mL. The solution was mixed and 5 mL were removed and pipetted into a plastic counting vial. These 5 mL samples became the reference solutions against which the samples of liquid were compared after contact with the solids. Approximately 2 grams of each solid was weighed out and placed in the individual bottles of tracer. Four samples of each solid were prepared.

One of the bottles of each set was sampled at 24 hours, again at 72 hours, and a third time at 168 hours to check the uptake kinetics. Sampling was done by removing about 5 mL of solution by plastic syringe and then filtering the liquid through a syringe filter (0.45  $\mu\text{m}$ ). This liquid was then pipetted into preweighed vials, which were reweighed to get the weight of the liquid.

Both the reference samples and the actual contact solutions were counted on an intrinsic germanium gamma detector with a Canberra spectroscopy system. The  $^{57}\text{Co}$ ,  $^{85}\text{Sr}$ , and  $^{137}\text{Cs}$  were measured at the 122, 514, and 661 keV gamma energies respectively. Because reference



solutions were used for each of the triplicate samples, there was no need to calculate activities of the post-contact samples. Instead counts per minute per gram (CPM/g) were compared directly and used in calculation of  $K_d$ .

The first set of tracer solutions was sampled after contact with the solids for 24, 72, and 168 hours. The other three from each set were left in contact for 144 hours. Kinetics results are shown in Figures 1 to 3, indicating that uptake for both tracers was essentially complete. The partition coefficient is calculated as the concentration of an element of interest sorbed on the solid phase, divided by that elements final concentration the liquid with which the solid was in contact. Results for  $^{57}\text{Co}$  are shown in Table 1. Results for  $^{85}\text{Sr}$  are shown in Table 2. Results for  $^{137}\text{Cs}$  are shown in Table 3. The pH of samples was measured after 336 hours; Clay A = 5.5, Crushed Rock A = 6.85, Sand = 5.32, and Gravel = 4.95.

**Table 1.**  
**Partition Coefficients for  $^{57}\text{Co}$**

Sample	Individual $K_d$ Values for $^{57}\text{Co}$	Average $K_d$
Clay	350, 455, 467, 516	447
Crushed Rock	156, 224, 204, 206	198
Bank Run Sand	368, 512, 557, 536	493
Bank Run Gravel	126, 460, 524, 493	401

**Table 2.**  
**Partition Coefficients for  $^{85}\text{Sr}$**

Sample	Individual $K_d$ Values for $^{85}\text{Sr}$	Average $K_d$
Clay	436, 438, 486, 474	459
Crushed Rock	41, 32, 48, 40	40
Bank Run Sand	143, 264, 275, 274	239

Bank Run Gravel	69, 160, 178, 181	147
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**Table 3.**  
**Partition Coefficients for  $^{137}\text{Cs}$**

Sample	Individual $K_p$ Values for $^{137}\text{Cs}$	Average $K_p$
Clay	1056, 998, 1136, 1337	1133
Crushed Rock	810, 1387, 1166, 1401	1191
Bank Run Sand	1105, 2250, 2140, 2337	1958
Bank Run Gravel	384, 1110, 1288, 1224	1001

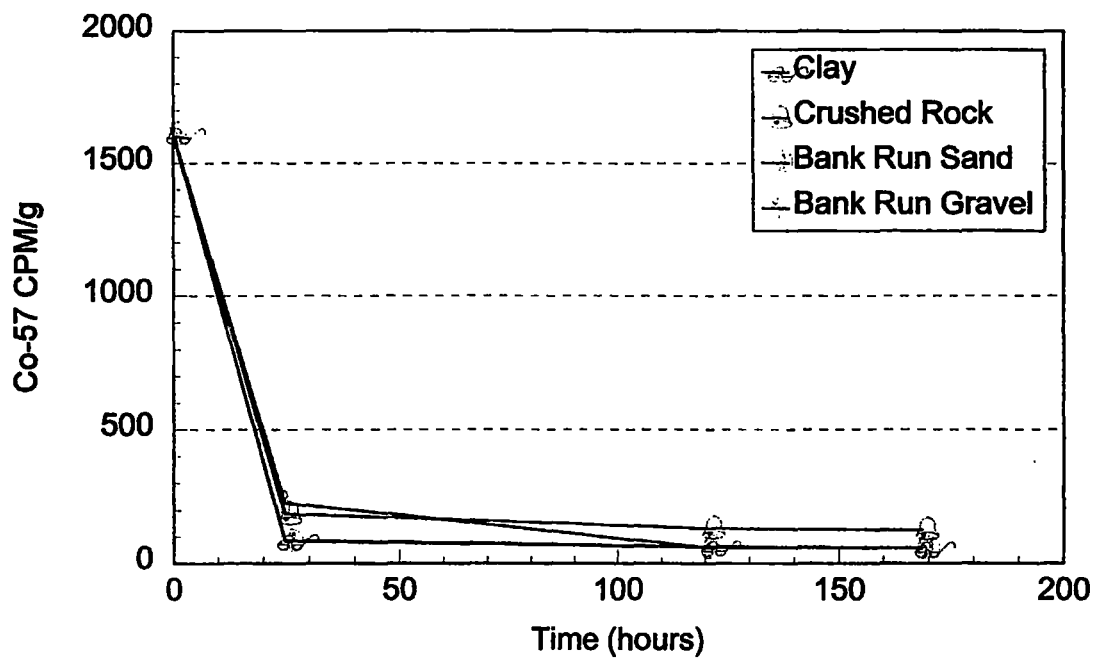
### $^{63}\text{Ni}$

Solutions containing  $^{63}\text{Ni}$  were prepared separately to allow for liquid scintillation counting. Preparations of the contact solutions were identical to those for the gamma emitting radionuclides. Sampling for measurements were different in that 1.0 mL of contact solution was withdrawn for counting, and mixed with 10 mL of Packard Ultima Gold liquid scintillation cocktail. An initial experimental solution was prepared and sampled after 24 hours. The remaining three solutions were sampled after 144 hours, since it was assumed that Ni would exhibit sorption kinetics similar to Co. Blank samples were also prepared to verify that leachable chemical constituents of the materials tested did not affect the quenching properties of the scintillator material. Samples were counted on a Wallac DSA for one minute each. Results for  $^{63}\text{Ni}$  are shown in Table 4. Values for pH of the blank contact solutions were determined after 168 hours.

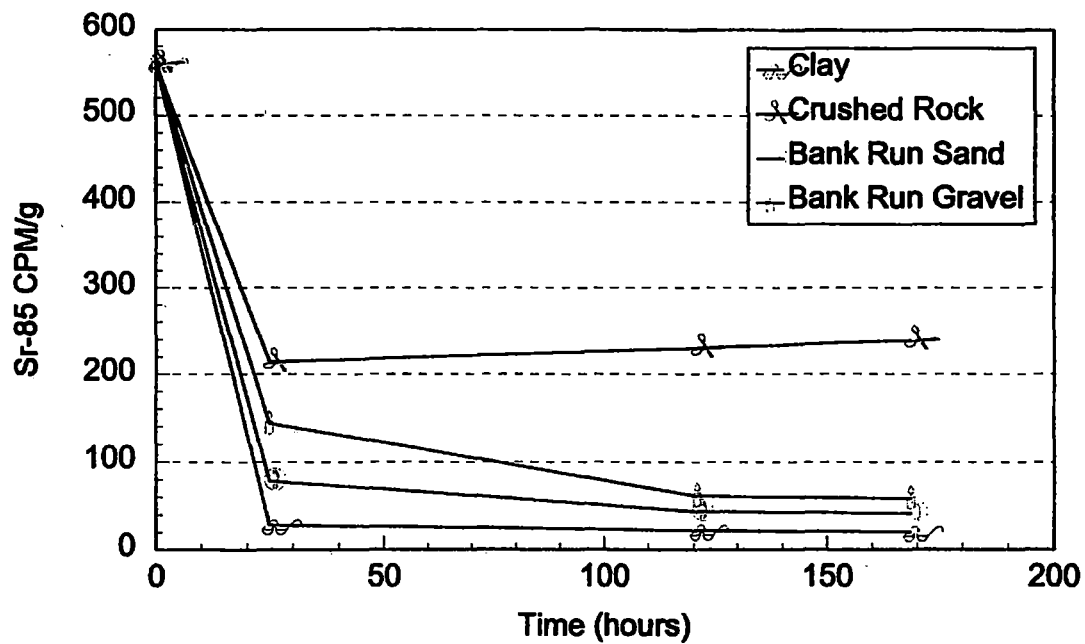
**Table 4.**  
**Partition Coefficients for  $^{63}\text{Ni}$**

Sample	Individual $K_p$ Values for $^{63}\text{Ni}$	Average $K_p$
Clay	262, 420, 565, 258	376
Crushed Rock	198, 199, 215, 224	209

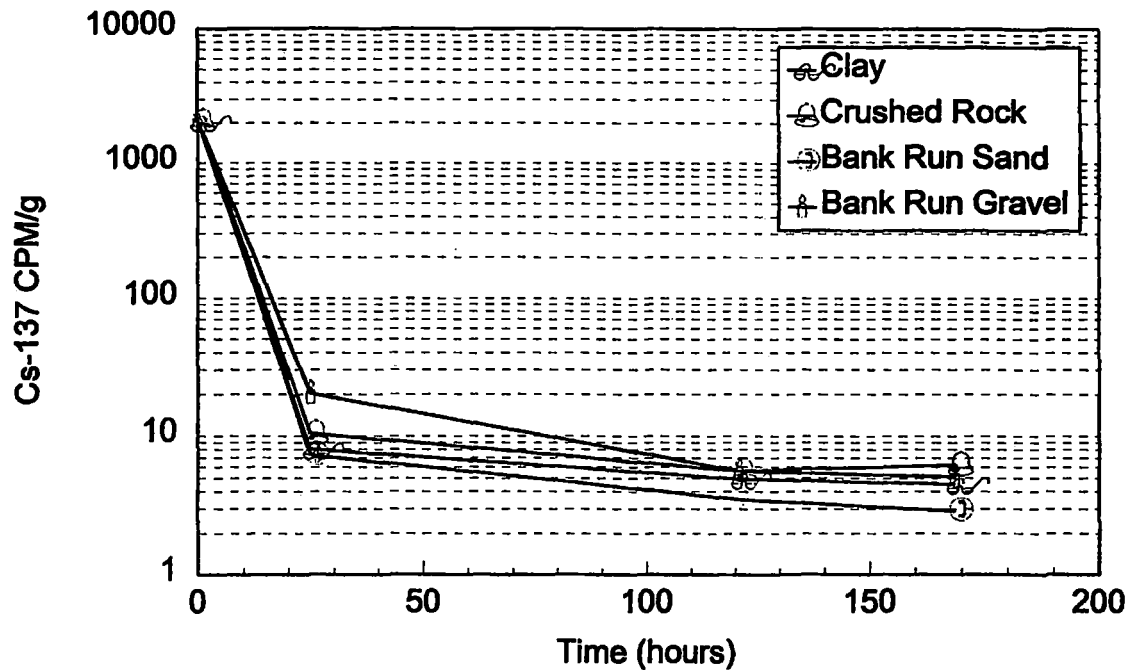
Bank Run Sand	220, 446, 521, 542	432
Bank Run Gravel	121, 240, 294, 402	264



**Figure 1. Uptake kinetics for Co-57 for the backfill materials.**



**Figure 2. Uptake kinetics for Sr-85 for the backfill materials.**



**Figure 3. Uptake kinetics of Cs-137 for the backfill materials.**

Please note that for the bank run gravel samples, we were not able to do the experiments with a large enough mass of solid that it would provide a representative value. Consequently the bank run gravel material was passed through a 4 mm (#5) sieve and that material was used for the  $K_D$  tests. To obtain the proper  $K_D$  for this material, the  $K_D$  should be multiplied by the fraction of material that passed the 4 mm sieve. We determined that 0.44 (44%) of the material was less than 4 mm; so each  $K_D$  value should be multiplied by 0.44 to obtain the correct value. Because our sample was relatively small for material containing so much gravel, it is advisable to check with the supplier to find out what fraction of the bulk material passes a No.5 sieve, and then correcting the  $K_D$  with that value.

## **Bulk Density**

### **Method**

Bulk density was determined in triplicate for the four materials. The bulk density of the clay was determined by placing a large (about 200 cc), preweighed, bolus of clay into a measured volume of water in a large graduated cylinder. The volume of the clay was determined by displacement.

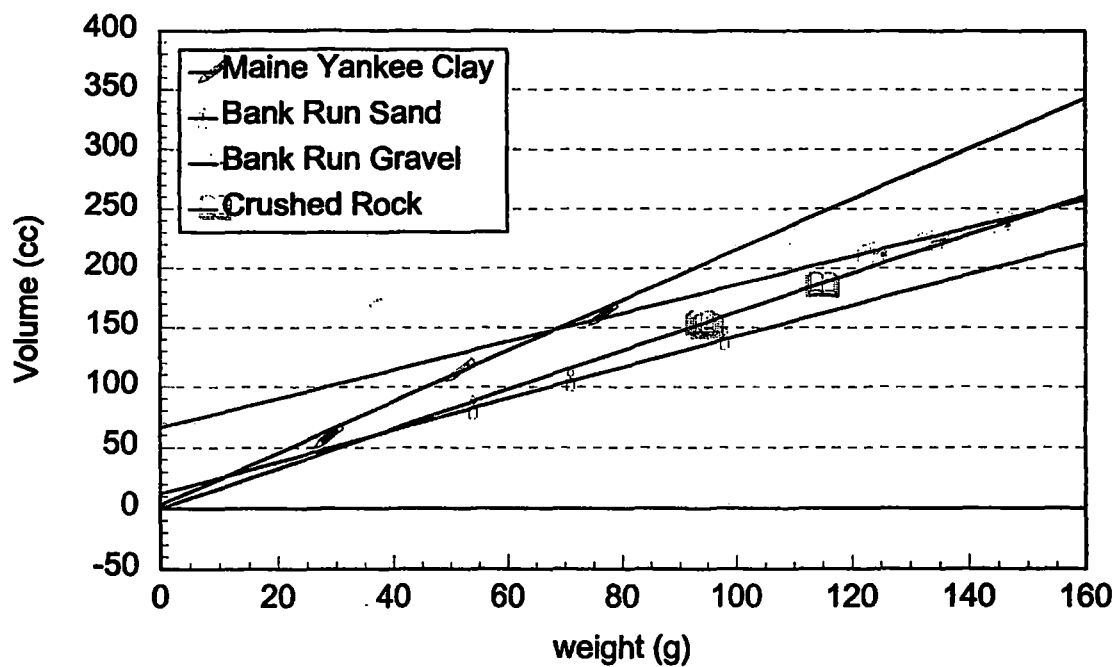
The other samples were not coherent and were poured into a graduated cylinder and were tamped down. The volume was measured from the graduations on the cylinder and then the sample was decanted and weighed.

### **Results**

These data are plotted on Figure 4, with the slope being the bulk density. All results are linear (typical  $R^2$  values were 0.98 or better) indicating good reproducibility. However, the bank run gravel samples did not produce a line that approached the origin. This indicates that we were not able to get a consistent mixture of sand and gravel for the samples. Bulk density values determined both as the slope from Figure 4 and by average are given in Table 5. It is recommended that the average values be used; the plots of the data and slope values are included to illustrate the small scatter in these determinations.

**Table 5.**  
**Bulk Density of Backfill Materials**

<b>Sample</b>	<b>Bulk density from the slope (g/cc)</b>	<b>Bulk density from averages (g/cc)</b>
Clay	2.13	2.18
Bank Run Sand	1.31	1.47
Bank Run Gravel	1.20	1.70
Crushed Rock	1.63	1.63



**Figure 4. Data for bulk density of backfill material.**

## **Partition Coefficients for Co, Cs, and Sr for Sand and Cementitious Backfill Materials for the Maine Yankee Site**

October 18, 2001

Mark Fuhrmann  
Environmental Sciences Department  
Brookhaven National Laboratory

### **Partition Coefficients**

#### **Method**

To determine the partition coefficients ( $K_D$ ) of Co, Cs, and Sr, two materials from the Maine Yankee site were exposed to low activity tracers of  $^{57}\text{Co}$ ,  $^{137}\text{Cs}$ , and  $^{85}\text{Sr}$ . The tracers each were prepared by initially diluting them from the "as received" concentrations of 100 Ci/mL to 4.76 Ci/mL. Two mL of each were mixed together and the pH was adjusted to 6.0, giving a final concentration of each tracer in the mixture of 0.476 Ci/mL.

For each sample of material to be tested, the contact solution was prepared by weighing out 44 g of distilled water into a plastic bottle and adding 0.5 mL of mixed tracer solution. The contact solution had a concentration of each tracer of 0.01 Ci/mL, or less. The solution was mixed and 2 mL were removed and pipetted into a plastic counting vial. These 2 mL samples became the reference solutions against which the samples of liquid were compared after contact with the solids. Approximately 2 grams of each solid (material that passed a 1mm sieve) were weighed out and placed in the individual bottles of tracer. After the 114 hour contact time, liquid samples were taken by removing about 3 mL of solution by plastic syringe and then filtering the liquid through a syringe filter (0.45  $\mu\text{m}$ ). Two mL of this liquid were then pipetted into preweighed vials, which were reweighed to get the weight of the liquid.

Both the reference samples and the actual contact solutions were counted on an intrinsic germanium gamma detector with a Canberra spectroscopy system. The  $^{57}\text{Co}$ ,  $^{85}\text{Sr}$ , and



$^{137}\text{Cs}$  were measured at the 122, 514, and 661 keV gamma energies respectively. Because reference solutions were used for each of the triplicate samples, there was no need to calculate activities of the post-contact samples. Instead counts per minute per gram (CPM/g) were compared directly and used in calculation of  $K_D$

The partition coefficient is calculated as the concentration of an element of interest sorbed on the solid phase, divided by that elements final concentration the liquid with which the solid was in contact. Results for  $^{57}\text{Co}$  are shown in Table 1. Results for  $^{85}\text{Sr}$  are shown in Table 2. Results for  $^{137}\text{Cs}$  are shown in Table 3.

**Table 1.**  
**Partition Coefficients for  $^{57}\text{Co}$**

<b>Material</b>	<b>Individual <math>K_D</math> Values for <math>^{57}\text{Co}</math> (mL/g)</b>	<b>Average <math>K_D</math></b>
Trial batch 99-932.2	188, 192, 186	189
Wiscasset Sand	633, 525, 597	585

**Table 2.**  
**Partition Coefficients for  $^{85}\text{Sr}$**

<b>Material</b>	<b>Individual <math>K_D</math> Values for <math>^{85}\text{Sr}</math> (mL/g)</b>	<b>Average <math>K_D</math></b>
Trial batch 99-932.2	102, 88, 77	89
Wiscasset Sand	1031, 761, 770	854

**Table 3.**  
**Partition Coefficients for  $^{137}\text{Cs}$**

<b>Material</b>	<b>Individual <math>K_D</math> Values for <math>^{137}\text{Cs}</math> (mL/g)</b>	<b>Average <math>K_D</math></b>
Trial batch 99-932.2	109, 130, 113	117
Wiscasset Sand	30980, 24400, 23340	26,200

The  $K_D$  values for the sand are significantly higher than those of the cement mix (Trial Batch 99-932.2). The cement supplies a large quantity of ions to solution, which compete with the radionuclide tracers for sorption sites on the sand. In addition it has agglomerated the sand so that sorption, which is a surface area based process, cannot proceed very effectively. The very high  $K_D$  values for  $^{137}\text{Cs}$  on the sand is an estimate because almost all of the  $^{137}\text{Cs}$  was sorbed by the sand, removing it from solution. Consequently the count rates for the liquid were very low; about 0.2 cpm/g, giving poor statistics even though count times were as long as 833 minutes. As a result, small changes in the very low count rate result in large changes in the  $K_D$ .

Both materials tested were passed through a 1mm sieve. The Wiscasset Sand contained 72.5% material that was less than 1 mm. The cement material was gently disaggregated with a spatula. It contained 67.6% material less than 1 mm. Assuming that material greater than 1mm has little or no capacity to sorb, the  $K_D$  needs to be corrected for the coarse fraction. Each  $K_D$  value should be multiplied by 0.725 or 0.676 (for the sand or cement materials respectively) to obtain the correct value. Because our sample was relatively small for material containing so much gravel, it is advisable to check with the supplier to find out what fraction of the bulk material passes a 1 mm sieve, and then correcting the  $K_D$  with that value.

**MYAPC License Termination Plan**  
**Revision 3**  
**October 15, 2002**

**Attachment 6-3**  
**BNL Kd Report for Concrete**

**TECHNICAL EVALUATION  
OF  
BNL  $K_d$  and Diffusion Coefficient Determination**

TE-99-041

**Purpose**

This evaluation documents the determination of partition and diffusion coefficients for concrete samples from Maine Yankee which were used to support the dose evaluation section (section 6) of the License Termination Plan. The studies were conducted by Brookhaven National Laboratory.

**References**

1. "Leaching and Sorption of Radionuclides: Structural Concrete from Maine Yankee Nuclear Power Station", BNL, October 21, 1999.

**Assumptions**

None

**Method**

Six samples of contaminated concrete and three sets of clean concrete were crushed and submitted for testing. An Accelerated Leach Test was performed on five of the contaminated samples using ASTM C-1308 methods. The leachant volume was 10 times the surface area of the solid samples and was composed of 1 liter of distilled/deionized water. Forty milliliter aliquots were removed at specified intervals for gamma spectroscopy. Estimated detection limits for both Cs-137 and Co-60 were 40 pCi/l. Count rates were converted to pCi/l and input to the Accelerated Leach Test (ALT) computer model. The ALT code output is a table of Incremental Fraction Leached (IFL) and the Cumulative Fraction Leached (CFL). The effective diffusion coefficient and goodness-of-fit were determined for both the Diffusion and Partition models.

The partition coefficient ( $K_d$ ) was determined for Cs-137 and Sr-90. Pieces of crushed concrete were immersed in distilled water containing the nuclide of interest. Uptake kinetics were determined by taking aliquots periodically, counting them and then returning them to the sample container. At the end of the test period, samples were filtered and counted. Sample count rates and reference count rates were determined. The  $K_d$  value was determined by dividing the count rate per gram of sample by the count rate per milliliter in the liquid. The pH of the leachate was also determined.

The DUST-MS code was used to determine the best fit effective diffusion coefficients from the

experimental data.

The details of the analytical methods are contained in reference 1 attached.

Conclusions

Based on the goodness-of-fit results, diffusion is the transport mechanism for concrete. The effective diffusion coefficient for Cs-137 was  $2\text{E-}10 \text{ cm}^2/\text{sec}$ .  $K_d$  values for cesium and strontium averaged 3.0 mL/g and 1.0 mL/g respectively.

Plant specific values of diffusion and partition coefficients have been determined for use in performing dose assessment calculations to support section 6 of the LTP.

Prepared By: [Signature] Date: 11/24/99

Reviewed By: [Signature] Date: 11/24/99

**Leaching and Sorption of Radionuclides:  
Structural Concrete from Maine Yankee  
Nuclear Power Station**

**November 9, 1999**

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### Summary

Six samples of contaminated structural concrete from the Maine Yankee Nuclear Power Station were received at Brookhaven National Laboratory (BNL) for leach testing. The leach test used is designed to determine if diffusion is the dominant rate controlling release mechanism from porous materials. If so the test method and computer code associated with it can be used to quantify the effective diffusion coefficient ( $D_e$ ). This approach assumes a homogeneously distributed contaminant in the leached sample. However, there is evidence that the contaminants are actually in a thin layer (1 mm or less) on the surface of the concrete core samples. To estimate an effective diffusion coefficient that is more representative of this condition, the DUST code was applied to the experimental data. As described in Appendix B, after reevaluating the leach rate relative to the geometry of the contaminant, the best fit  $D_e$  for  $^{137}\text{Cs}$  from the sample with the greatest leach rate (sample 4A) was  $2 \times 10^{-10} \text{ cm}^2/\text{sec}$ .

Three sets of uncontaminated, crushed concrete were tested to determine partition coefficients ( $K_d$ ) for  $^{137}\text{Cs}$  and  $^{85}\text{Sr}$ . With these tests the quantities of  $^{137}\text{Cs}$  and  $^{85}\text{Sr}$  that sorbed onto the fractured concrete were determined. Uptake of  $^{137}\text{Cs}$  yielded a  $K_d$  of 3.0. For  $^{90}\text{Sr}$  the  $K_d$  was 3.0. These values can be used as input to the DUST code to determine how much sorption reduces releases from the facility.

### METHODS

The Accelerated Leach Test (ASTM C-1308) was started for five samples on September 14, 1999. With the observation that these samples all had coatings of paint or epoxy on them, one of the samples was removed from testing and two additional samples (with the epoxy removed) were sent to BNL. These samples were added to the test set, starting on September 20, 1999. The leach test was run according to the test protocol. The leachant volume was 10 times the surface area of the solid sample, with the volume of distilled/deionized water used for each sample, in each interval, being about 1.0 liter. All weighing was done on calibrated and recently certified balances. Sample parameters are given in Table 1.

Aliquots of 40 mL were taken at each interval for gamma spectroscopy. All samples were counted in the same geometry containers. Two intrinsic germanium gamma detectors were used. Each was calibrated with a NIST traceable mixed gamma standard (#678-59) from Isotope Products Laboratories. This standard contained both  $^{137}\text{Cs}$  and  $^{60}\text{Co}$ , which allowed direct comparisons to the leaching samples. The standard was diluted and counted in the same geometry as the samples, on each detector. At the end of the counting campaign, samples of distilled/deionized water were counted as blanks, again in the same geometry, for 2000 minutes each. One detector was observed to have a low background for  $^{137}\text{Cs}$ , which was subtracted from the data obtained with that detector.

Count rates were converted to pCi/L on an Excel spread sheet, and then input to the Accelerated Leach Test (ALT) computer model. Estimated detection limits for both  $^{137}\text{Cs}$  and  $^{60}\text{Co}$  are 40 pCi/L. The parameters used in the calculations are shown in Table 1 for each sample. Spread sheets for each sample are included in Appendix A. Output of the code is a sheet that tabulates the Incremental Fraction Leached (IFL) and the Cumulative Fraction Leached (CFL). The effective diffusion coefficient and "goodness-of-fit" parameter are also given for both the Diffusion and Partition models. Figures showing the CFL as a function of time are also included in Appendix A.

The partition coefficient ( $K_d$ ) was experimentally determined for  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$ . Pieces of broken concrete from Maine Yankee were contacted with distilled water (adjusted to pH = 7.0) that contained the radionuclide of interest. As shown in Fig. 1, 3-6 pieces were used, each being about 2 cm. Uptake kinetics were determined by taking periodic samples of the water, counting it and then returning it to the experiment. Experiments were started by weighing out distilled water, adding tracer, and then taking an aliquot as a reference. At the end of the experiment about 5 mL were withdrawn with a plastic syringe, and the water was pushed through a 0.45 micron syringe filter. Aliquots were pipetted into preweighed vials; the vials were then reweighed and counted. Uptake on the concrete was determined by taking the difference in count rates between the



sample and the reference. The  $K_d$  is the count rate per gram on the solid divided by the count rate per mL in the liquid, at steady-state. After sampling, pH measurements were taken from the leachate. The instrument was standardized with newly made pH reference solutions at 7.0 and 4.01.



Figure 1. Samples of concrete used in the  $^{137}\text{Cs}$  experiment for  $K_d$  determination.

**Table 1.**

**Concrete Samples for Leach Testing**

<b>Sample</b>	<b>Weight (g)</b>	<b>Diameter (cm)</b>	<b>Height (cm)</b>	<b>Leachant Volume (L)</b>	<b>Source Term Cs-137 (pCi)</b>	<b>Source Term Co-60 (pCi)</b>
1A	117.4	6.97	1.41	1.070	372,100	200
2A	105.4	6.89	1.36	1.040	553,300	359,700
4A	125.2	6.91	1.46	1.070	249,200	200
8A*	103.8	6.92	1.16	1.000	25,000	31,900
32A	93.8	6.95	1.17	1.010	336,000	19,100
41A	101.0	6.92	1.42	1.060	113,000	21,100

\* Sample 8A contains 30,100 pCi of Eu-152.

## RESULTS

Results of the leach tests are summarized in Table 2. Effective diffusion coefficients for  $^{137}\text{Cs}$  range from  $9 \times 10^{-9}$  to  $5 \times 10^{-11}$   $\text{cm}^2/\text{sec}$ . One of the bare concrete samples leached the fastest while the other was very slow. Alternatively, there may still be some epoxy in the pores of the bare concrete with the low leach rate. Effective diffusion coefficients for  $^{60}\text{Co}$  were about the same or somewhat lower than  $^{137}\text{Cs}$ . In some of the samples, inventories were so low that no  $^{60}\text{Co}$  could be detected in the leachate. No releases of  $^{152}\text{Eu}$  were observed from sample 8A.

Releases of  $^{137}\text{Cs}$  fit the diffusion model very well. Generally if the goodness-of-fit parameter is less than 2%, the fit of the model to the data indicates diffusion as the transport mechanism. All of the samples have goodness-of-fit values for  $^{137}\text{Cs}$  lower than 2%; with most being significantly lower than 1%. The samples (2A and 41A) with high values had thick layers of epoxy on their contaminated surfaces. For these samples several processes or rates may be controlling  $^{137}\text{Cs}$  releases. It is likely that diffusion at several rates (from the epoxy and the concrete) presents an averaged rate to produce the observed leaching curve. For  $^{60}\text{Co}$ , sample 2A had a goodness-of-fit value of 0.35% while 8A had 2.38%. Leaching data, ALT output, and figures showing the cumulative fraction released as a function of time, are given in Appendix A.

The results presented above assume that the source term is distributed, homogeneously, through the entire sample. However, there is evidence that the activity on the concrete is actually in a 1 mm thick layer at the concrete surface. Because the diffusion coefficient is very sensitive to the path length through the sample, the ALT model was run using a 1mm thickness for sample 4A as well as the measured 14 mm. At 14 mm,  $D_e$  for  $^{137}\text{Cs}$  was  $8 \times 10^{-9}$   $\text{cm}^2/\text{sec}$ . When the thickness was altered to 1 mm,  $D_e$  for  $^{137}\text{Cs}$  was  $7 \times 10^{-11}$   $\text{cm}^2/\text{sec}$ , with no change in the "goodness-of-fit" parameter. The diffusion coefficient responds to the reduction in thickness by becoming lower by almost two orders of magnitude, in order to keep the fraction released the same (as was observed experimentally). This estimated  $D_e$  is based on releases from both sides of a uniformly

contaminated cylinder. There is evidence that the contamination actually resides in a 1mm thick layer which is backed by clean concrete. To examine this case in detail the DUST-MS computer code was used. Results of this analysis are discussed in Appendix B. From this modeling a best fit effective diffusion coefficient for Cs (for sample 4A) was estimated to be  $2 \times 10^{-10}$  cm<sup>2</sup>/sec. This is based on a 1 mm thick contaminated layer with clean concrete on one side and water on the other.

Effective diffusion coefficients for <sup>60</sup>Co were determined for only two of the six samples; those with the greatest inventories of the radionuclide. Concentrations were below detection limits in the leachate from the other samples. Observed values of  $D_e$  were  $1 \times 10^{-10}$  and  $3 \times 10^{-11}$ , which were calculated based on a homogeneous distribution of the contaminant in the sample. It is believed that <sup>60</sup>Co is actually present in a layer of about 0.2 mm thickness. This being the case, the value of  $D_e$  would decrease by an order of magnitude or more.

No <sup>152</sup>Eu was observed in the leachate although it was specifically searched for. This is not surprising because rare earths typically partition strongly to the solid phase. Moreover, sample 8A, the only one containing observable activities of this radionuclide, represents material that was activated. One would therefore expect <sup>152</sup>Eu to be retained in minerals in the aggregate (or the cement itself) that contained the traces of Eu that were activated.

Partition coefficients were determined for <sup>137</sup>Cs and <sup>85</sup>Sr in contact with structural concrete obtained from the site. Kinetics of uptake were examined for <sup>137</sup>Cs to determine the correct contact time for the experiment. Figure 2 shows that <sup>137</sup>Cs uptake follows a square root of time function and is mostly complete by 160 hours. The <sup>137</sup>Cs  $K_d$  sampling was done at that time. Results for <sup>137</sup>Cs and <sup>85</sup>Sr are given in tables 3 and 4 respectively. Values of  $K_d$  for <sup>137</sup>Cs average 3.0 mL/g; while for <sup>85</sup>Sr the average is 1.0 mL/g.

**Table 2.**  
**Summary of Radionuclide Leaching from Structural Concrete**  
**Maine Yankee Nuclear Power Station**

Sample	Description	D, Cs-137 cm <sup>2</sup> /S	Cs-137 goodness of fit	Fraction Leached Cs-137	D, Co-60 cm <sup>2</sup> /S	Fraction Leached Co-60	pH of final sample
1A	Bare concrete, epoxy removed	$5.6 \times 10^{-11}$	0.22	0.019	—	—	7.9
2A	Concrete with two layers of epoxy, ~1mm thick	$4.9 \times 10^{-11}$	1.74	0.015	$1.03 \times 10^{-10}$	0.027	6.9
4A	Bare concrete, epoxy removed	$8.0 \times 10^{-9}$	0.35	0.195	—	—	6.5
8A	Concrete with a thin layer of white paint	$3.3 \times 10^{-9}$	0.07	0.146	$3.3 \times 10^{-11}$	0.019	7.6
32A	Concrete with a thin layer of white paint	$4.6 \times 10^{-10}$	0.51	0.058	—	—	7.5
41A	Concrete with three layers ~ 2mm thick	$8.0 \times 10^{-11}$	1.21	0.020	—	—	6.3

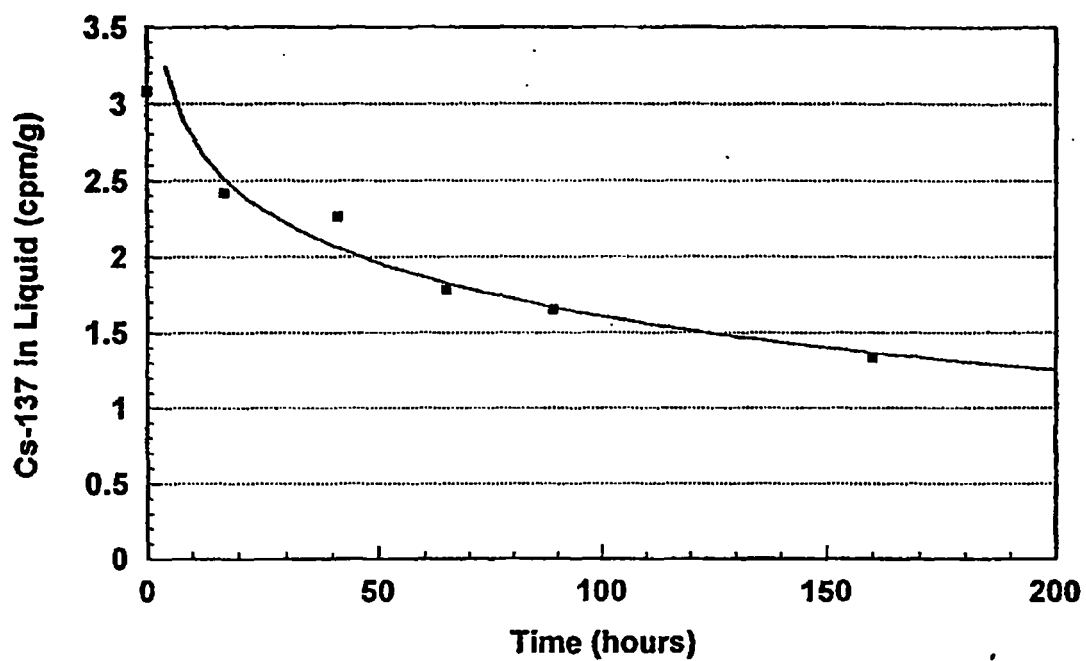


Figure 2. Kinetics of Cs-137 uptake on structural concrete from Maine Yankee.

**Table 3.**  
 **$K_d$  Values for Cs-137 in Contact with Yankee Concrete Samples**

Contact Time: 160 hours

Sample	Start CPM/g	End CPM/g	$\Delta$ CPM/g	Liquid Volume (g)	Concrete Wt (g)	Counts on Solid CPM/g	$K_d$ Cs-137	pH
1B	3.08	1.33	1.75	48.4	16.900	5.01	2.9	11.2
2B	2.93	1.82	1.11	48.6	18.294	2.95	2.7	11.5
3B	2.93	1.46	1.47	48.4	14.575	4.88	3.3	11.32

**Table 4**  
 **$K_d$  Values for Sr-85 in Contact with Yankee Concrete Samples**

Contact Time: 143 hours

Sample	Start CPM/g	End CPM/g	$\Delta$ CPM/g	Liquid Volume (mL)	Concrete Wt (g)	Counts on Solid CPM/g	$K_d$ Sr-85	pH
1	16.96	13.13	3.83	50.0	15.35	9.54	0.73	11.1
2	18.05	14.60	3.45	50.0	12.32	14.00	0.96	11.3
3	13.78	10.85	2.93	50.0	10.70	13.69	1.26	11.2

**MYAPC License Termination Plan  
Revision 3  
October 15, 2002**

**Attachment 6-4  
Irrigation Memorandum**



**MEMO**

**Date:** ~~10-20-99~~

**To:** George Pillsbury

**From:** Robert F. Decker

**Subject:** TE99-020 documentation of telephone calls from USDA/NRCS representatives

On September 1, 1999 an e-mail was sent to Norman Kalloch, USDA-NRCS representative in the Orono, ME (207 990-9100) regarding local (Lincoln County) well irrigation rates. Unfortunately, his office was in the process of changing over to a new server system and the message was not received until some time later. On September 10, 1999 Mr. Kalloch contacted me by telephone. During the conversation Mr. Kalloch confirmed that agriculture in Maine does not rely to any significant extent on well or surface water irrigation. The majority of irrigation occurs in the northern portion of the State and is primarily associated with potato crops. To provide local agricultural irrigation information Mr. Kalloch directed me to contact Ms. Mary Thompson in Warren Maine. Ms. Thompson is the local Lincoln county extension representative (207 273- 2005).

On September 10, 1999 following the conversation with Mr. Kalloch I contacted Mary Thompson. Ms. Thompson stated that precipitation (rain) is the principal source of irrigation for family gardens. She said that local irrigation rates from wells would not be expected to exceed 4-5 inches per year for family gardens and 7-8 inches per year for commercial growers. She stated that these rates are relative to drought years, normal years would result in less well irrigation. She also stated that pumping cost for family and commercial growers is a contributing factor for the stated irrigation rates as are low well production rates especially during drought years where there is a greater concern for conserving the water for domestic usage. Ms. Thompson also stated that in the coastal region salt water intrusion of the well is also a consideration by local residents. This latter concern is a significant consideration during drought years. Ms. Thompson forwarded the latest copy of the USDA report for local irrigation and farm usage. Ms. Thompson concluded that the principal local commercial crops irrigated are strawberries.

On September 16, 1999 I was contacted by Paul Hughes (207 990-9100 #3) the USDA agronomist for Maine. Mr. Hughes confirmed the conditions and rates provided by Mr. Kalloch and Ms. Thompson and reiterated the reasons and conditions provided by Ms. Thompson regarding local well usage. Mr. Hughes concluded that recommendations to commercial strawberries growers was to provide the crops one inch of water per week. The recommendations to commercial growers is to supplement their crops to a 1 inch per week rate with irrigation water if the weekly rainfall is less than one inch per week.

**MYAPC License Termination Plan**  
**Revision 3**  
**October 15, 2002**

**Attachment 6-5**  
**Concrete Density**

TECHNICAL EVALUATION  
OF  
Concrete Porosity and Density

TE-99-039

Purpose

This TE documents the porosity and density of Maine Yankee concrete samples as determined by Earth Engineering Services, Inc. of Baltimore, Maryland.

References

1. Letter dated June 9, 1999 from Earth Engineering.
2. ASTM C 642-97, "Standard Test Method for Density, Absorption, and Voids in Hardened Concrete.

Assumptions

None

Method

Clean concrete samples from Maine Yankee were submitted to Earth Engineering Services, Inc. for analysis in order to determine the porosity and density. ASTM test method C 642-97 was followed for performing the analyses.

The results of the analyses were as follows;

	<u>Core# A9900/01FL2</u>	<u>Core# A9900/01MC3</u>
Bulk Density	2.21 g/cc	2.27 g/cc
Porosity	14.6%	13.7%

Conclusion

The density and porosity of concrete at the Maine Yankee site have been determined using standard test methods.

Prepared By: [Signature] Date: 11/22/99

Reviewed By: Robert P. Decker Date: 12/3/99. Calculations (attached) checked for correctness & verified RFE



3401 CARLINS PARK DRIVE BALTIMORE, MARYLAND 21215 (410) 466-1400 FAX: (410) 466-7371

June 9, 1999

Maine Yankee Atomic Power Plant  
Stone & Webster Decommissioning Team  
Old Ferry and Bailey Point Road  
Wiscasset, ME 04578

Attention: Mr. Robert J. Tozzie  
Stone & Webster/ Radiological Services, Inc.

Re: Concrete Core Samples  
Bulk Density & Porosity Tests  
E2Si Project No. 99-160

Dear Mr. Tozzie:

Test results for the 2 core samples are summarized below.

	CORE #A9900/01FL2	CORE #A9900/01MC3
Bulk Density (Dry)	2.21	2.27
Bulk Density After Immersion	2.34	2.38
Bulk Density After Immersion & Boiling	2.36	2.40
Apparent Density	2.59	2.63
Permeable Pore Space (voids)	14.6%	13.7%

\* Density in units of grams per cubic centimeter

If we can be of further assistance, please contact us.

Very truly yours,

EARTH ENGINEERING & SCIENCES, INC.

  
Paul A. D'Amato, P.E.  
Vice President

FAD/cw/proj.doc/SAW

Geotechnical • Inspection • Testing • Instrumentation • Soil/Rock Drilling



SUBJECT	Maine Yankee	
Concrete Core - Bulk Density and Porosity	SHEET NO.	1 OF 1
	JOB NO.	99-160
	BY	PAD DATE 6/8/99
	CHK'D	DATE
	REV.	DATE

Reference: ASTM C 642

Core # A9900/01FL2 (5.8" Dia)

Oven Dry Weight = 2956.8 gm  
 Saturated Wt. After Immersion = 3125.0 gm  
 Saturated Wt. After Boiling = 3151.6 gm  
 Immersed Wt. = 1816.0 gm

$$\text{Bulk Density (dry)} = 2956.8 / (3151.6 - 1816.0) = 2.21$$

$$\text{Bulk Density (After Immersion)} = 3125.0 / (3151.6 - 1816.0) = 2.34$$

$$\text{Bulk Density (After Immersion \& Boiling)} = 3151.6 / (3151.6 - 1816.0) = 2.36$$

$$\text{Apparent Density} = 2956.8 / (2956.8 - 1816.0) = 2.59$$

$$\text{Permeable Pore Space (voids)} = (3151.6 - 2956.8) / (3151.6 - 1816.0) = 0.146 = 14.6\%$$

Core # A9900/01ME3 (2.7" Dia)

Oven Dry Weight = 1082.1 gm  
 Saturated Wt. After Immersion = 1139.3 gm  
 Saturated Wt. After Boiling = 1147.7 gm  
 Immersed Weight = 670.0 gm

$$\text{Bulk Density (Dry)} = 1082.1 / (1147.7 - 670.0) = 2.27$$

$$\text{Bulk Density After Immersion} = 1139.3 / (1147.7 - 670.0) = 2.38$$

$$\text{Bulk Density After Immersion \& Boiling} = 1147.7 / (1147.7 - 670.0) = 2.40$$

$$\text{Apparent Density} = 1082.1 / (1082.1 - 670.0) = 2.63$$

$$\text{Permeable Pore Space (voids)} = (1147.7 - 1082.1) / (1147.7 - 670.0) = 0.137 = 13.7\%$$



Designation: C 642 - 97

## Standard Test Method for Density, Absorption, and Voids in Hardened Concrete<sup>1</sup>

This standard is issued under the fixed designation C 642; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This test method covers the determinations of density, percent absorption, and percent voids in hardened concrete.

1.2 The text of this test method references notes and footnotes which provide explanatory information. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of this standard.

### 2. Significance and Use

2.1 This test method is useful in developing the data required for conversions between mass and volume for concrete. It can be used to determine conformance with specifications for concrete and to show differences from place to place within a mass of concrete.

### 3. Apparatus

3.1 *Balance*, sensitive to 0.025 % of the mass of the specimen.

3.2 *Container*, suitable for immersing the specimen and suitable wire for suspending the specimen in water.

### 4. Test Specimen

4.1 Whenever possible, the sample shall consist of several individual portions of concrete, each to be tested separately. The individual portions may be pieces of cylinders, cores, or beams of any desired shape or size, except that the volume of each portion shall be not less than 350 cm<sup>3</sup> (or for normal weight concrete, approximately 800 g); and each portion shall be free from observable cracks, fissures, or shattered edges.

### 5. Procedure

5.1 *Oven-Dry Mass*—Determine the mass of the portions, and dry in an oven at a temperature of 100 to 110°C for not less than 24 h. After removing each specimen from the oven, allow it to cool in dry air (preferably in a desiccator) to a temperature of 20 to 25°C and determine the mass. If the specimen was comparatively dry when its mass was first determined, and the second mass closely agrees with the first, consider it dry. If the specimen was wet when its mass was first determined, place it in the oven for a second drying treatment of 24 h and again determine the mass. If the third value checks the second, consider the specimen dry. In case of any doubt, redry the specimen for 24-h periods until check values of mass are obtained. If the difference between values

obtained from two successive values of mass exceeds 0.5 % of the lesser value, return the specimens to the oven for an additional 24-h drying period, and repeat the procedure until the difference between any two successive values is less than 0.5 % of the lowest value obtained. Designate this last value *A*.

5.2 *Saturated Mass After Immersion*—Immerse the specimen, after final drying, cooling, and determination of mass, in water at approximately 21°C for not less than 48 h and until two successive values of mass of the surface-dried sample at intervals of 24 h show an increase in mass of less than 0.5 % of the larger value. Surface-dry the specimen by removing surface moisture with a towel, and determine the mass. Designate the final surface-dry mass after immersion *B*.

5.3 *Saturated Mass After Boiling*—Place the specimen, processed as described in 5.2, in a suitable receptacle, covered with tap water, and boil for 5 h. Allow it to cool by natural loss of heat for not less than 14 h to a final temperature of 20 to 25°C. Remove the surface moisture with a towel and determine the mass of the specimen. Designate the soaked, boiled, surface-dried mass *C*.

5.4 *Immersed Apparent Mass*—Suspend the specimen, after immersion and boiling, by a wire and determine the apparent mass in water. Designate this apparent mass *D*.

### 6. Calculation

6.1 By using the values for mass determined in accordance with the procedures described in Section 5, make the following calculations:

$$\text{Absorption after immersion, \%} = [(B - A)/A] \times 100 \quad (1)$$

$$\text{Absorption after immersion and boiling, \%} = [(C - A)/A] \times 100 \quad (2)$$

$$\text{Bulk density, dry} = [A/(C - D)] \cdot \rho = g_1 \quad (3)$$

$$\text{Bulk density after immersion} = [B/(C - D)] \cdot \rho \quad (4)$$

$$\text{Bulk density after immersion and boiling} = [C/(C - D)] \cdot \rho \quad (5)$$

$$\text{Apparent density} = [A/(A - D)] \cdot \rho = g_2 \quad (6)$$

$$\text{Volume of permeable pore space (voids), \%} = (g_2 - g_1)/g_2 \times 100 \quad (7)$$

$$\text{or } (C - A)/(C - D) \times 100$$

where:

*A* = mass of oven-dried sample in air, g

*B* = mass of surface-dry sample in air after immersion, g

*C* = mass of surface-dry sample in air after immersion and boiling, g

*D* = apparent mass of sample in water after immersion and boiling, g

$g_1$  = bulk density, dry, Mg/m<sup>3</sup> and

$g_2$  = apparent density, Mg/m<sup>3</sup>

$\rho$  = density of water = 1 Mg/m<sup>3</sup> = 1 g/cm<sup>3</sup>.

### 7. Example

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<sup>1</sup> This test method is under the jurisdiction of ASTM Committee C-9 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.69 on Miscellaneous Tests.

Current edition approved Jan. 10, 1997. Published March 1997. Originally published as C 642 - 69 T. Last previous edition C 642 - 90.

## C 642

## 7. Example

7.1 Assume a sample having the following characteristics:

7.1.1 Mass of the solid part of the specimen = 1000 g.

7.1.2 Total volume of specimen (including solids, "permeable" voids, and "impermeable" voids) = 600 cm<sup>3</sup>.

7.1.3 Absolute density of solid part of specimen = 2.0 Mg/m<sup>3</sup>.

7.1.4 Void space in specimen contains initially only air (no water).

7.2 Then, it follows that there are 500 cm<sup>3</sup> of solids and 100 cm<sup>3</sup> of voids making up the specimen, and the void content is 1/6 = 16.67 %.

7.3 Assume that on immersion 90 mL of water is absorbed.

7.4 Assume that after immersion and boiling 95 mL of water is absorbed.

7.5 Based on the assumptions given in 7.1 to 7.4 above, the data that would be developed from the procedures given in Section 5 would be as follows:

7.5.1 Oven-dry mass,  $A = 1000$  g.

7.5.2 Mass in air after immersion,  $B = 1090$  g.

7.5.3 Mass in air after immersion and boiling,  $C = 1095$  g.

7.5.4 Apparent mass in water after immersion and boiling,  $D = 495$  g.

NOTE 1—Since loss of mass in water is equal to mass of displaced water, and volume of specimen = 600 cm<sup>3</sup>, mass of specimen in water after immersion and boiling is 1095 - 600 = 495 g.

7.6 By using the data given above to perform the calculations described in Section 6, the following results will be obtained (Note 2):

Absorption after immersion, % =  $[(B - A)/A] \times 100$   
 $= [(1090 - 1000)/1000] \times 100 = 9.0$

Absorption after immersion and boiling, % =  $[(C - A)/A] \times 100$   
 $= [(1095 - 1000)/1000] \times 100 = 9.5$

Bulk density, dry =  $[A/(C - D)] \cdot \rho = [1000/(1095 - 495)] \times 1$   
 $= 1.67 \text{ Mg/m}^3 = g_1$

Bulk density after immersion  
 $= [B/(C - D)] \cdot \rho = [1090/(1095 - 495)] \times 1 = 1.82$

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This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 100 Barr Harbor Drive, West Conshohocken, PA 19428.

Bulk density after immersion and boiling

$$= [C/(C - D)] \cdot \rho = [1095/(1095 - 495)] \times 1 = 1.83 \text{ Mg/m}^3$$

Apparent density =  $[A/(A - D)] \cdot \rho = [1000/(1000 - 495)] \times 1$   
 $= 1.98 \text{ Mg/m}^3 = g_2$

Volume of permeable voids, %

$$= [(g_2 - g_1)/g_2] \times 100 = [(1.98 - 1.67)/1.98] \times 100$$

$$= 15.8, \text{ or } [(C - A)/(C - D)] \times 100$$

$$= [(1095 - 1000)/(1095 - 495)] \times 100 = 15.7$$

NOTE 2—This test method does not involve a determination of absolute density. Hence, such pore space as may be present in the specimen that is not emptied during the specified drying or is not filled with water during the specified immersion and boiling or both is considered "impermeable" and is not differentiated from the solid portion of the specimen for the calculations, especially those for percent voids. In the example discussed it was assumed that the absolute density of the solid portion of the specimen was 2.0 Mg/m<sup>3</sup>, the total void space was 16.67 %, and the impermeable void space was 5 cm<sup>3</sup>. The operations, if performed, and the calculations, if performed as described, have the effect of assuming that there are 95 cm<sup>3</sup> of pore space and 505 cm<sup>3</sup> of solids, and indicate that the solid material, therefore, has an apparent density of 1.98 rather than the absolute density of 2.00 Mg/m<sup>3</sup> and the specimen has a percentage of voids of 15.8 rather than 16.67.

Depending on the pore size distribution and the pore entry radii of the concrete and on the purposes for which the test results are desired, the procedures of this test method may be adequate, or they may be insufficiently rigorous. In the event that it is desired to fill more of the pores than will be filled by immersion and boiling, various techniques involving the use of vacuum treatment or increased pressures may be used. If a rigorous measure of total pore space is desired, this can only be obtained by determining absolute density by first reducing the sample to discrete particles, each of which is sufficiently small so that no impermeable pore space can exist within any of the particles. If the absolute density were determined and designated  $g_3$ , then:

$$\text{Total void volume, \%} = (g_3 - g_1)/g_3 \times 100$$

$$= (2.00 - 1.67)/2.00 \times 100 = 16.5$$

## 8. Precision and Bias

8.1 Precision—At present there are insufficient data available to justify attempting to develop a precision statement for this test method.

8.2 Bias—Bias for this test method cannot be determined since there is no reference standard available for comparison.

## 9. Keywords

9.1 absorption; concrete-hardened; density; voids

**MYAPC License Termination Plan**  
**Revision 4**  
**February 28, 2005**

**Attachment 6-6**  
**Deleted**



**MYAPC License Termination Plan**  
**Revision 3**  
**October 15, 2002**

**Attachment 6-7**  
**Embedded Piping List**

### Remaining Embedded Piping

No.	Location	Pen No.	Length (ft)	Embedded Diameter (in.)	Surface Area (m <sup>2</sup> )
	<b>Primary Auxiliary Building To Containment</b>				
1	Steam Generator Blowdown	45	5.0	16.0	1.945
2	Reactor Coolant Letdown	32	5.0	16.0	1.945
3	Primary Component Cooling Reactor Coolant Pump	6	5.0	6.0	0.729
4	Primary Drain Transfer Pump Discharge	39	5.0	3.0	0.365
5	Spare	41	5.0	2.0	0.243
6	Air Recirculation Cooling Water (out)	21	5.0	6.0	0.729
7	Air Recirculation Cooling Water (out)	20	5.0	6.0	0.729
8	Air Recirculation Cooling Water (out)	19	5.0	6.0	0.729
9	Air Recirculation Cooling Water (out)	18	5.0	6.0	0.729
10	Air Recirculation Cooling Water (out)	17	5.0	6.0	0.729
11	Air Recirculation Cooling Water (in)	10	5.0	6.0	0.729
12	Air Recirculation Cooling Water (in)	11	5.0	6.0	0.729
13	Air Recirculation Cooling Water (in)	12	5.0	6.0	0.729
14	Air Recirculation Cooling Water (in)	13	5.0	6.0	0.729
15	Air Recirculation Cooling Water (in)	14	5.0	6.0	0.729
16	Steam Generator Blowdown Lines	47	5.0	16.0	1.945
17	Auxiliary Steam	46	5.0	16.0	1.945
18	Spare	82	5.0	4.0	0.486
19	Air Recirculation Cooling Water (out)	16	5.0	6.0	0.729
20	Air Recirculation Cooling Water (out)	15	5.0	6.0	0.729
21	Containment Isolation & Safeguards Pressure Switch Header	63	5.0	8.0	0.973
22	Pressurizer Steam Interface and Pressurizer Safety Valve Loop	62	5.0	8.0	0.973
23	Containment Leak Detection	61	5.0	8.0	0.973
24	Seal Water From Reactor Coolant Pump	23	5.0	3.0	0.365
25	Spare	25	5.0	4.0	0.486
26	Primary Component Cooling Water From CRDM Coolers	86	5.0	4.0	0.486
27	Primary Vent Header	24	5.0	2.0	0.243
28	Aerated Vent Header	42	5.0	2.0	0.243
29	Steam Generator Auxiliary Feedwater	75	5.0	16.0	1.945

### Remaining Embedded Piping

No.	Location	Pen No.	Length (ft)	Embedded Diameter (in.)	Surface Area (m <sup>2</sup> )
30	Charging	22	5.0	3.0	0.365
31	High Pressure Safety Injection	72	5.0	4.0	0.486
32	Spare	69	5.0	8.0	0.973
33	Spare	40	5.0	3.0	0.365
34	Spare, Chemical Cleaning During Construction	74	5.0	8.0	0.973
35	Spare	2	5.0	1.5	0.182
36	Steam Generator Auxiliary Feedwater	76	5.0	8.0	0.973
37	Spare	77	5.0	8.0	0.973
38	Primary Component Cooling From High Pressure/Low Pressure Shield Tank Coolers	5	5.0	6.0	0.729
39	Primary Component Cooling Water From CRDM Coolers	89	5.0	4.0	0.486
40	Spare	1	5.0	1.5	0.182
41	Spare	88	5.0	4.0	0.486
42	Spare	87	5.0	4.0	0.486
43	Injection Seal Water to Reactor Cooling Pump	26	5.0	1.5	0.182
44	Primary Component Cooling From High Pressure/Low Pressure Drain Shield Coolers a& Neutron Tank Shield Coolers	4	5.0	6.0	0.729
45	Primary Component Cooling to Reactor Cooling Pumps	3	5.0	6.0	0.729
46	Demineralizer Water to Quench Tank	37	5.0	2.0	0.243
47	Nitrogen To Quench and Safety Injection Tanks	44	5.0	1.0	0.122
48	Instrument Air	49	5.0	1.5	0.182
49	Spare	90	5.0	6.0	0.729
50	Spare	80	5.0	6.0	0.729
51	Service Air	48	5.0	2.0	0.243
52	High Pressure Safety Injection	71	5.0	4.0	0.486
53	High Pressure Safety Injection	73	5.0	4.0	0.486
54	Spare	43	5.0	0.75	0.091
55	Post Accident Purge	84	5.0	2.0	0.243
56	Refueling Cavity Purification (out)	79	5.0	6.0	0.729
57	Spare	91	5.0	6.0	0.729
58	Spare	83	5.0	4.0	0.486
59	Spare	85	5.0	3.0	0.365

### Remaining Embedded Piping

No.	Location	Pen No.	Length (ft)	Embedded Diameter (in.)	Surface Area (m <sup>2</sup> )
60	Spare	38	5.0	4.0	0.486
61	Sump Pump Discharge	92	5.0	2.0	0.243
62	Air Monitor Sample	59	5.0	1.0	0.122
63	Primary Component Cooling to and from Penetration Coolers	81	5.0	8.0	0.973
64	Spare	78	5.0	8.0	0.973
65	Neutron Shield Tank Fill	35	5.0	1.5	0.182
66	Air Monitor Sample	60	5.0	1.0	0.122
67	Spare	7	5.0	3.0	0.365
68	Spare	8	5.0	3.0	0.365
69	Injection Seal Water to Reactor Coolant Pump	28	5.0	1.5	0.182
70	Injection Seal Water to Reactor Coolant Pump	27	5.0	1.5	0.182
71	Reactor Coolant Loop Fill	36	5.0	2.0	0.243
72	Fire Water Supply (North Wall)	154	2.0	8.0	0.389
	<b>South Wall Primary Auxiliary Building To Yard</b>				
73	Ric-Wil	23	2.0	20.5	0.997
74	Primary Water	276	2.0	2.0	0.097
75	Ric-Wil	24	2.0	22.0	1.070
76	Secondary Component Cooling	282	2.0	1.5	0.073
77	Demineralized Water to Storage Tank	5	2.0	4.0	0.195
78	Secondary Component Cooling	4	2.0	2.0	0.097
79	Primary Component Cooling	3	2.0	16.0	0.778
80	Primary Component Cooling	41	2.0	16.0	0.778
81	Borated Water to Sump	26	2.0	4.0	0.195
	<b>Containment Spray Pump Building</b>				
82	Drain Line from Main Steam Valve House and Personnel Hatch (East Wall)		2.25	6.0	0.328
83	Ric-Wil (East Wall)		2.25	16.0	0.875
84	Ric-Wil (East Wall)		2.25	16.0	0.875
85	Ric-Wil (South East Wall)		3.0	19.0	1.386
86	Ric-Wil (South East Wall)		3.0	12.0	0.875
87	Ric-Wil (South East Wall)		3.0	14.0	1.021

### Remaining Embedded Piping

No.	Location	Pen No.	Length (ft)	Embedded Diameter (in.)	Surface Area (m <sup>2</sup> )
88	Secondary Component Cooling Supply to E-3B (South East Wall)		3.0	16.0	1.167
89	Secondary Component Cooling Return to E-3B (South East Wall)		3.0	16.0	1.167
90	Purification to Refueling Water Storage Tank (South West Wall)		3.0	6.0	0.438
91	Ric-Wil (South West Wall)		3.0	19.0	1.386
92	Ric-Wil (South West Wall)		3.0	22.0	1.605
93	Ric-Wil (South West Wall)		3.0	22.0	1.605
94	Primary Component Cooling Supply to E-3A (South West Wall)		3.0	14.0	1.021
95	Primary Component Cooling Return From E-3A (South West Wall)		3.0	14.0	1.021
	<b>Containment Spray Pump Building To Containment</b>				
96	Residual Heat Remover (out)	9	5.0	30.0	3.647
97	Low Pressure Steam Injection and Residual Heat Remover (in)	29	5.0	30.0	3.647
98	Low Pressure Steam Injection and Residual Heat Remover (in)	30	5.0	30.0	3.647
99	Low Pressure Steam Injection and Residual Heat Remover (in)	31	5.0	30.0	3.647
100	Low Pressure Steam Injection and Containment Spray Pump Suction	33	34.0	16.0	13.228
101	Low Pressure Steam Injection and Containment Spray Pump Suction	34	34.0	16.0	13.228
102	Containment Spray Supply <sup>1</sup>	50	5.0	24.0	2.918
103	Containment Spray Supply (See Note 1 related to Item No. 102.)	51	5.0	24.0	2.918
104	Safety Injection Test and Safety Injection Tank Liquid Sample	68	5.0	2.0	0.243
105	Spare	70	5.0	10.0	1.216
106	Containment Spray Pump Casing Vent	93	5.0	2.0	0.243
	<b>Fuel Building To Containment</b>				
107	Fuel Transfer Tube	52	11.0	40.0	10.669
	<b>Miscellaneous</b>				
108	Liner Leak Detection system		4 x 6.0	4 ea. @ 1.0	0.584
109	Containment Foundation Drain		122.0	6.0	17.799
110	Containment Foundation Drain		256.0	2.0	12.450
	<b>Totals:</b>		940.75		154.2

<sup>1</sup> The subject 24" containment spray supply lines have been removed; however, the associated activity inventory was included in the dose assessment. See also, Section 6.7.2.

**MYAPC License Termination Plan**  
**Revision 3**  
**October 15, 2002**

**Attachment 6-8**  
**Deep Soil Microshield Output**

Microshield  
Deep Soil Direct Dose  
Unitized Values

This attachment provides the Microshield outputs for direct dose factors for deep soil. No output is provided for H-3 or Ni-63 because they have no contribution to direct dose. The area size is 10,000 m<sup>2</sup> by 2.85 m deep. Soil density is 1.6 g/cm<sup>3</sup>. The dose point is 1 meter above the soil surface.

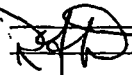

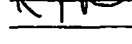
Then direct dose factors are determined by multiplying the fraction of the time spent indoors (0.6571) by the external gamma shielding factor (0.5512) then adding the fraction of time spent outdoors (0.1101). The resulting number is multiplied by 24 hours per day for 365 days per year.

Nuclide	Direct Dose Factor (mrem/y per pCi/g)
H-3	0.00E+00
Ni-63	0.00E+00
Co-60	2.4E+00
Cs-137	4.00E-01

MicroShield v5.01 (5.01-00010)  
Maine Yankee Atomic Power

Page : 1  
DOS File: Casel  
Run Date: September 24, 2002  
Run Time: 2:30:37 PM  
Duration: 00:00:02

Attachment 6-8  
Page 3 of 5

File Ref:   
Date:   
By:   
Checked: \_\_\_\_\_

Case Title: Deep Soil Cs-137  
Description: Direct Dose Rate for Unit Activity  
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	285.0 cm	9 ft 4.2 in
Width	1.0e+4 cm	328 ft 1.0 in
Height	1.0e+4 cm	328 ft 1.0 in

Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	400 cm	5000 cm	5000 cm
	13 ft 1.5 in	164 ft 0.5 in	164 ft 0.5 in

Shields

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	2.85e+10 cm <sup>3</sup>	SiO <sub>2</sub>	1.6
Shield 1	15.0 cm	SiO <sub>2</sub>	1.6
Air Gap		Air	0.00122

Source Input

Grouping Method : Actual Photon Energies

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>μCi/cm<sup>3</sup></u>	<u>Bq/cm<sup>3</sup></u>
Ba-137m	4.5600e-002	1.6872e+009	1.6000e-006	5.9200e-002
Cs-137	4.5600e-002	1.6872e+009	1.6000e-006	5.9200e-002

Buildup

The material reference is : Source

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

Results

<u>Energy</u>	<u>Activity</u>	<u>Fluence Rate</u>	<u>Fluence Rate</u>	<u>Exposure Rate</u>	<u>Exposure Rate</u>
<u>MeV</u>	<u>photons/sec</u>	<u>MeV/cm<sup>2</sup>/sec</u>	<u>MeV/cm<sup>2</sup>/sec</u>	<u>mR/hr</u>	<u>mR/hr</u>
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.0318	3.493e+07	4.855e-18	1.532e-17	4.044e-20	1.276e-19
0.0322	6.445e+07	2.210e-17	7.140e-17	1.778e-19	5.746e-19
0.0364	2.345e+07	1.818e-14	7.670e-14	1.033e-16	4.358e-16
0.6616	1.518e+09	8.579e-03	6.022e-02	1.663e-05	1.167e-04
TOTALS:	1.641e+09	8.579e-03	6.022e-02	1.663e-05	1.167e-04



Attachment 6-8  
Page 4 of 5

MicroShield v5.01 (5.01-00010)  
Maine Yankee Atomic Power  
Conversion of calculated exposure in air to dose  
FILE: Case1



Case Title: Deep Soil Cs-137  
This case was run on Tuesday, September 24, 2002 at 2:40:54 PM  
Dose Point # 1 - (400,5000,5000) cm

<u>Results (Summed over energies)</u>	<u>Units</u>	<u>Without Buildup</u>	<u>With Buildup</u>
Photon Fluence Rate (flux)	Photons/cm <sup>2</sup> /sec	1.297e-002	9.101e-002
Photon Energy Fluence Rate	MeV/cm <sup>2</sup> /sec	8.579e-003	6.022e-002
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.663e-005	1.167e-004
Absorbed Dose Rate in Air	mGy/hr	1.452e-007	1.019e-006
"	mrads/hr	1.452e-005	1.019e-004
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.719e-007	1.207e-006
o Opposed	"	1.376e-007	9.661e-007
o Rotational	"	1.376e-007	9.661e-007
o Isotropic	"	1.217e-007	8.543e-007
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.827e-007	1.282e-006
o Opposed	"	1.735e-007	1.218e-006
o Rotational	"	1.735e-007	1.218e-006
o Isotropic	"	1.301e-007	9.132e-007
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.520e-007	1.067e-006
o Posterior/Anterior	"	1.342e-007	9.418e-007
o Lateral	"	9.950e-008	6.983e-007
o Rotational	"	1.199e-007	8.416e-007
o Isotropic	"	1.021e-007	7.165e-007

Attachment 6-8  
Page 5 of 5

**MicroShield v5.01 (5.01-00010)**  
**Maine Yankee Atomic Power**  
**Conversion of calculated exposure in air to dose**  
**FILE: Case1**



**Case Title: Deep Soil Co-60**  
**This case was run on Tuesday, September 24, 2002 at 2:35:00 PM**  
**Dose Point # 1 - (400,5000,5000) cm**

<u>Results (Summed over energies)</u>	<u>Units</u>	<u>Without Buildup</u>	<u>With Buildup</u>
Photon Fluence Rate (flux)	Photons/cm <sup>2</sup> /sec	7.381e-002	3.092e-001
Photon Energy Fluence Rate	MeV/cm <sup>2</sup> /sec	9.300e-002	3.884e-001
<b>Exposure and Dose Rates:</b>			
Exposure Rate in Air	mR/hr	1.634e-004	6.829e-004
Absorbed Dose Rate in Air	mGy/hr	1.427e-006	5.962e-006
"	mrad/hr	1.427e-004	5.962e-004
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.620e-006	6.770e-006
o Opposed	"	1.394e-006	5.826e-006
o Rotational	"	1.394e-006	5.826e-006
o Isotropic	"	1.245e-006	5.203e-006
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.725e-006	7.209e-006
o Opposed	"	1.660e-006	6.939e-006
o Rotational	"	1.660e-006	6.939e-006
o Isotropic	"	1.320e-006	5.515e-006
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.459e-006	6.096e-006
o Posterior/Anterior	"	1.343e-006	5.613e-006
o Lateral	"	1.068e-006	4.460e-006
o Rotational	"	1.209e-006	5.053e-006
o Isotropic	"	1.070e-006	4.470e-006

**Attachment 6-9**  
**Deep Soil RESRAD Output**

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Dose Conversion Factor (and Related) Parameter Summary  
 File: FGR 13 Morbidity

Menu	Parameter	Current Value	Default	Parameter Name
B-1 B-1	Dose conversion factors for inhalation, mrem/pCi: Co-60	2.190E-04	2.190E-04	DCF2( 1)
D-1 D-1	Dose conversion factors for ingestion, mrem/pCi: Co-60	2.690E-05	2.690E-05	DCF3( 1)
D-34	Food transfer factors:			
D-34	Co-60 , plant/soil concentration ratio, dimensionless	8.000E-02	8.000E-02	RTF( 1,1)
D-34	Co-60 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-02	2.000E-02	RTF( 1,2)
D-34	Co-60 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-03	2.000E-03	RTF( 1,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Co-60 , fish	3.000E+02	3.000E+02	BIOFAC( 1,1)
D-5	Co-60 , crustacea and mollusks	2.000E+02	2.000E+02	BIOFAC( 1,2)

RESRAD, Version 6.1      T½ Limit = 0.5 year  
Summary : RESRAD Default Parameters09/24/2002 11:52 Page 3  
File: deepsoil1061802Cob405.RAD

## Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	1.000E+04	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	2.850E+00	2.000E+00	---	THICKO
R011	Length parallel to aquifer flow (m)	1.000E+02	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	1.000E+01	2.500E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.900E-01	1.000E+00	---	T( 2)
R011	Times for calculations (yr)	2.000E-01	3.000E+00	---	T( 3)
R011	Times for calculations (yr)	1.000E+00	1.000E+01	---	T( 4)
R011	Times for calculations (yr)	7.100E+00	3.000E+01	---	T( 5)
R011	Times for calculations (yr)	4.270E+01	1.000E+02	---	T( 6)
R011	Times for calculations (yr)	1.300E+02	3.000E+02	---	T( 7)
R011	Times for calculations (yr)	1.340E+02	1.000E+03	---	T( 8)
R011	Times for calculations (yr)	1.500E+02	0.000E+00	---	T( 9)
R011	Times for calculations (yr)	1.000E+03	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Co-60	1.000E+00	0.000E+00	---	S1( 1)
R012	Concentration in groundwater (pCi/L): Co-60	not used	0.000E+00	---	W1( 1)
R013	Cover depth (m)	1.500E-01	0.000E+00	---	COVERO
R013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.600E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	3.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	3.200E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	4.050E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.000E+00	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.000E+06	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	1.600E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	3.000E-01	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	1.000E-02	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	2.000E-01	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	3.200E+01	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	2.000E-02	2.000E-02	---	HGWT
R014	Saturated zone b parameter	4.050E+00	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	1.000E-03	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	1.000E+01	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	not used	2.500E+02	---	UW
R015	Number of unsaturated zone strata	1	1	---	NS

RESRAD, Version 6.1      T½ Limit = 0.5 year  
Summary : RESRAD Default Parameters09/24/2002 12:21 Page 3  
File: deepsoil061802Cob405.RAD

## Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	1.000E+04	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	2.850E+00	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	1.000E+02	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	1.000E+01	2.500E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.900E-01	1.000E+00	---	T( 2)
R011	Times for calculations (yr)	2.000E-01	3.000E+00	---	T( 3)
R011	Times for calculations (yr)	1.000E+00	1.000E+01	---	T( 4)
R011	Times for calculations (yr)	7.100E+00	3.000E+01	---	T( 5)
R011	Times for calculations (yr)	4.270E+01	1.000E+02	---	T( 6)
R011	Times for calculations (yr)	1.300E+02	3.000E+02	---	T( 7)
R011	Times for calculations (yr)	1.340E+02	1.000E+03	---	T( 8)
R011	Times for calculations (yr)	1.500E+02	0.000E+00	---	T( 9)
R011	Times for calculations (yr)	1.000E+03	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Co-60	1.000E+00	0.000E+00	---	S1( 1)
R012	Concentration in groundwater (pCi/L): Co-60	not used	0.000E+00	---	W1( 1)
R013	Cover depth (m)	1.500E-01	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.600E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	3.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	3.200E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	4.050E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.000E+00	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.000E+06	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	1.600E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	3.000E-01	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	1.000E-02	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	2.000E-01	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	3.200E+01	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	2.000E-02	2.000E-02	---	HGWT
R014	Saturated zone b parameter	4.050E+00	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	1.000E-03	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	1.000E+01	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	not used	2.500E+02	---	UW
R015	Number of unsaturated zone strata	1	1	---	NS

RESRAD, Version 6.1      T<sub>1/2</sub> Limit = 0.5 year  
Summary : RESRAD Default Parameters09/24/2002 12:22 Page 3  
File: deepsoil061802Ni63b405.RAD

## Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	1.000E+04	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	2.850E+00	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	1.000E+02	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	1.000E+01	2.500E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.900E-01	1.000E+00	---	T ( 2)
R011	Times for calculations (yr)	2.000E-01	3.000E+00	---	T ( 3)
R011	Times for calculations (yr)	1.000E+00	1.000E+01	---	T ( 4)
R011	Times for calculations (yr)	7.100E+00	3.000E+01	---	T ( 5)
R011	Times for calculations (yr)	4.270E+01	1.000E+02	---	T ( 6)
R011	Times for calculations (yr)	1.300E+02	3.000E+02	---	T ( 7)
R011	Times for calculations (yr)	1.344E+02	1.000E+03	---	T ( 8)
R011	Times for calculations (yr)	1.500E+02	0.000E+00	---	T ( 9)
R011	Times for calculations (yr)	1.000E+03	0.000E+00	---	T (10)
R012	Initial principal radionuclide (pCi/g): Ni-63	1.000E+00	0.000E+00	---	S1 ( 1)
R012	Concentration in groundwater (pCi/L): Ni-63	not used	0.000E+00	---	W1 ( 1)
R013	Cover depth (m)	1.500E-01	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.600E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	3.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	3.200E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	4.050E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.000E+00	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.000E+06	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	1.600E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	3.000E-01	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	1.000E-02	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	2.000E-01	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	3.200E+01	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	2.000E-02	2.000E-02	---	HGWT
R014	Saturated zone b parameter	4.050E+00	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	1.000E-03	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	1.000E+01	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	not used	2.500E+02	---	UW
R015	Number of unsaturated zone strata	1	1	---	NS



Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	1.000E+04	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	2.850E+00	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	1.000E+02	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	1.000E+01	2.500E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.900E-01	1.000E+00	---	T ( 2)
R011	Times for calculations (yr)	2.000E-01	3.000E+00	---	T ( 3)
R011	Times for calculations (yr)	1.000E+00	1.000E+01	---	T ( 4)
R011	Times for calculations (yr)	7.100E+00	3.000E+01	---	T ( 5)
R011	Times for calculations (yr)	4.270E+01	1.000E+02	---	T ( 6)
R011	Times for calculations (yr)	1.340E+02	3.000E+02	---	T ( 7)
R011	Times for calculations (yr)	1.500E+02	1.000E+03	---	T ( 8)
R011	Times for calculations (yr)	1.000E+03	0.000E+00	---	T ( 9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): H-3	1.000E+00	0.000E+00	---	SI ( 1)
R012	Concentration in groundwater (pCi/L): H-3	not used	0.000E+00	---	WI ( 1)
R013	Cover depth (m)	1.500E-01	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.600E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	3.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	3.200E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	4.050E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.000E+00	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.000E+06	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	1.600E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	3.000E-01	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	1.000E-02	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	2.000E-01	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	3.200E+01	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	2.000E-02	2.000E-02	---	HGWT
R014	Saturated zone b parameter	4.050E+00	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	1.000E-03	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	1.000E+01	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	not used	2.500E+02	---	UW
R015	Number of unsaturated zone strata	1	1	---	NS

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R015	Unsat. zone 1, thickness (m)	0.000E+00	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	1.600E+00	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	3.000E-01	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	2.000E-01	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	2.000E-01	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	4.050E+00	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	1.000E+03	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Cs-137				
R016	Contaminated zone (cm**3/g)	1.200E+03	1.000E+03	---	DCNUCC( 1)
R016	Unsaturated zone 1 (cm**3/g)	1.200E+03	1.000E+03	---	DCNUCU( 1,1)
R016	Saturated zone (cm**3/g)	1.200E+03	1.000E+03	---	DCNUCS( 1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	9.136E-05	ALEACH( 1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK( 1)
R017	Inhalation rate (m**3/yr)	not used	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	not used	1.000E-04	---	MLINH
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	not used	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	not used	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	not used	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	not used	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	not used	1.000E+00	>0 shows circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE( 1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE( 2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE( 3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE( 4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE( 5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE( 6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE( 7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE( 8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE( 9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA( 1)
R017	Ring 2	not used	2.732E-01	---	FRACA( 2)
R017	Ring 3	not used	0.000E+00	---	FRACA( 3)
R017	Ring 4	not used	0.000E+00	---	FRACA( 4)
R017	Ring 5	not used	0.000E+00	---	FRACA( 5)
R017	Ring 6	not used	0.000E+00	---	FRACA( 6)
R017	Ring 7	not used	0.000E+00	---	FRACA( 7)
R017	Ring 8	not used	0.000E+00	---	FRACA( 8)
R017	Ring 9	not used	0.000E+00	---	FRACA( 9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)

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Summary : RESRAD Default Parameters

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## Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R015	Unsat. zone 1, thickness (m)	0.000E+00	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	1.600E+00	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	3.000E-01	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	2.000E-01	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	2.000E-01	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	4.050E+00	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	1.000E+03	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Co-60.				
R016	Contaminated zone (cm**3/g)	3.350E+02	1.000E+03	---	DCNUCC( 1)
R016	Unsaturated zone 1 (cm**3/g)	3.350E+02	1.000E+03	---	DCNUCU( 1,1)
R016	Saturated zone (cm**3/g)	3.350E+02	1.000E+03	---	DCNUCS( 1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.272E-04	ALEACH( 1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK( 1)
R017	Inhalation rate (m**3/yr)	not used	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	not used	1.000E-04	---	MLINH
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	not used	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	not used	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	not used	5.000E-01	---	FTND
R017	Fraction of time spent outdoors (on site)	not used	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	not used	1.000E+00	>0 shows circular AREA.	FS
R017	Radial of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE( 1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE( 2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE( 3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE( 4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE( 5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE( 6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE( 7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE( 8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE( 9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA( 1)
R017	Ring 2	not used	2.732E-01	---	FRACA( 2)
R017	Ring 3	not used	0.000E+00	---	FRACA( 3)
R017	Ring 4	not used	0.000E+00	---	FRACA( 4)
R017	Ring 5	not used	0.000E+00	---	FRACA( 5)
R017	Ring 6	not used	0.000E+00	---	FRACA( 6)
R017	Ring 7	not used	0.000E+00	---	FRACA( 7)
R017	Ring 8	not used	0.000E+00	---	FRACA( 8)
R017	Ring 9	not used	0.000E+00	---	FRACA( 9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)

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 Summary : RESRAD Default Parameters File: deepsoil061802Ni63b405.RAD

## Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R015	Unsat. zone 1, thickness (m)	0.000E+00	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	1.600E+00	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	3.000E-01	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	2.000E-01	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	2.000E-01	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	4.050E+00	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	1.000E+03	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Ni-63				
R016	Contaminated zone (cm**3/g)	2.740E+02	1.000E+03	---	DCNUCC( 1)
R016	Unsaturated zone 1 (cm**3/g)	2.740E+02	1.000E+03	---	DCNUCU( 1,1)
R016	Saturated zone (cm**3/g)	2.740E+02	1.000E+03	---	DCNUCS( 1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.000E-04	ALEACH( 1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK( 1)
R017	Inhalation rate (m**3/yr)	not used	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	not used	1.000E-04	---	MLINH
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	not used	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	not used	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	not used	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	not used	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	not used	1.000E+00	>0 shows circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE( 1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE( 2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE( 3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE( 4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE( 5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE( 6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE( 7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE( 8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE( 9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA( 1)
R017	Ring 2	not used	2.732E-01	---	FRACA( 2)
R017	Ring 3	not used	0.000E+00	---	FRACA( 3)
R017	Ring 4	not used	0.000E+00	---	FRACA( 4)
R017	Ring 5	not used	0.000E+00	---	FRACA( 5)
R017	Ring 6	not used	0.000E+00	---	FRACA( 6)
R017	Ring 7	not used	0.000E+00	---	FRACA( 7)
R017	Ring 8	not used	0.000E+00	---	FRACA( 8)
R017	Ring 9	not used	0.000E+00	---	FRACA( 9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R015	Unsat. zone 1, thickness (m)	0.000E+00	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	1.600E+00	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	3.000E-01	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	2.000E-01	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	2.000E-01	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	4.050E+00	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	1.000E+03	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for H-3				
R016	Contaminated zone (cm**3/g)	0.000E+00	0.000E+00	---	DCNUCC( 1)
R016	Unsaturated zone 1 (cm**3/g)	0.000E+00	0.000E+00	---	DCNUCU( 1,1)
R016	Saturated zone (cm**3/g)	0.000E+00	0.000E+00	---	DCNUCS( 1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	8.506E-01	ALEACH( 1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK( 1)
R017	Inhalation rate (m**3/yr)	not used	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	not used	1.000E-04	---	MLINH
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	not used	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	not used	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	not used	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	not used	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	not used	1.000E+00	>0 shows circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE( 1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE( 2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE( 3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE( 4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE( 5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE( 6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE( 7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE( 8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE( 9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA( 1)
R017	Ring 2	not used	2.732E-01	---	FRACA( 2)
R017	Ring 3	not used	0.000E+00	---	FRACA( 3)
R017	Ring 4	not used	0.000E+00	---	FRACA( 4)
R017	Ring 5	not used	0.000E+00	---	FRACA( 5)
R017	Ring 6	not used	0.000E+00	---	FRACA( 6)
R017	Ring 7	not used	0.000E+00	---	FRACA( 7)
R017	Ring 8	not used	0.000E+00	---	FRACA( 8)
R017	Ring 9	not used	0.000E+00	---	FRACA( 9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R018	Fruits, vegetables and grain consumption (kg/yr)	not used	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	not used	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	not used	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	not used	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	not used	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	not used	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	not used	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	4.785E+02	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	1.000E+00	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	not used	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	not used	1.000E+00	---	FIW
R018	Contamination fraction of aquatic food	not used	5.000E-01	---	FR9
R018	Contamination fraction of plant food	not used	-1	---	FPLANT
R018	Contamination fraction of meat	not used	-1	---	FMEAT
R018	Contamination fraction of milk	not used	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	not used	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	not used	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	not used	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	not used	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	not used	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	not used	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	not used	1.500E-01	---	DM
R019	Depth of roots (m)	not used	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	1.000E+00	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	not used	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	not used	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	not used	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	not used	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	not used	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	not used	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	not used	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	not used	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	not used	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	not used	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	not used	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	not used	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR

RESRAD, Version 6.1 T<sub>1/2</sub> Limit = 0.5 year  
 Summary : RESRAD Default Parameters

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 File: deepsoil061802csb405.RAD

## Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
C14	DCF correction factor for gaseous forms of C14	not used	8.894E+01	---	CO2F
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSEFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	suppressed
2 -- inhalation (w/o radon)	suppressed
3 -- plant ingestion	suppressed
4 -- meat ingestion	suppressed
5 -- milk ingestion	suppressed
6 -- aquatic foods	suppressed
7 -- drinking water	active
8 -- soil ingestion	suppressed
9 -- radon	suppressed
Find peak pathway doses	active



RESRAD, Version 6.1 T<sub>1/2</sub> Limit = 0.5 year 09/24/2002 12:26 Page 8  
Summary : RESRAD Default Parameters File: deepsoil061802csb405.RAD

<u>Contaminated Zone Dimensions</u>		<u>Initial Soil Concentrations, pCi/g</u>	
Area:	10000.00 square meters	Cs-137	1.000E+00
Thickness:	2.85 meters		
Cover Depth:	0.15 meters		

Total Dose TDOSE(t), mrem/yr  
Basic Radiation Dose Limit = 1.000E+01 mrem/yr  
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.900E-01	2.000E-01	1.000E+00	7.100E+00	4.270E+01	1.300E+02	1.340E+02	1.500E+02	1.000E+03
TDOSE(t):	6.647E-06	9.153E-06	9.285E-06	1.961E-05	8.650E-05	2.158E-04	8.644E-05	8.121E-05	6.275E-05	1.070E-12
M(t):	6.647E-07	9.153E-07	9.285E-07	1.961E-06	8.650E-06	2.158E-05	8.644E-06	8.121E-06	6.275E-06	1.070E-13

Maximum TDOSE(t): 2.158E-04 mrem/yr at t = 42.70 ± 0.09 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 4.270E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 4.270E+01 years

Water Dependent Pathways

Radio- Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	2.158E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.158E-04	1.0000
Total	2.158E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.158E-04	1.0000

\*Sum of all water independent and dependent pathways.

RESRAD, Version 6.1 T<sub>1/2</sub> Limit = 0.5 year 09/24/2002 12:27 Page 8  
Summary : RESRAD Default Parameters File: deepsoil061802Cob405.RAD

<u>Contaminated Zone Dimensions</u>		<u>Initial Soil Concentrations, pCi/g</u>	
Area:	10000.00 square meters	Co-60	1.000E+00
Thickness:	2.85 meters		
Cover Depth:	0.15 meters		

Total Dose TDOSE(t), mrem/yr  
Basic Radiation Dose Limit = 1.000E+01 mrem/yr  
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.900E-01	2.000E-01	1.000E+00	7.100E+00	4.270E+01	1.300E+02	1.340E+02	1.500E+02	1.000E+03
TDOSE(t):	4.721E-05	6.401E-05	6.487E-05	1.264E-04	2.891E-04	1.516E-05	4.670E-10	2.843E-10	3.870E-11	0.000E+00
M(t):	4.721E-06	6.401E-06	6.487E-06	1.264E-05	2.891E-05	1.516E-06	4.670E-11	2.843E-11	3.870E-12	0.000E+00

Maximum TDOSE(t): 2.891E-04 mrem/yr at t = 7.11 ± 0.01 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 7.110E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Co-60	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 7.110E+00 years

Water Dependent Pathways

Radio- Nuclide Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Co-60	2.891E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.891E-04	1.00
Total	2.891E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.891E-04	1.00

\*Sum of all water independent and dependent pathways.

RESRAD, Version 6.1 T<sub>1/2</sub> Limit = 0.5 year 09/24/2002 12:28 Page 8  
Summary : RESRAD Default Parameters File: deepsoil061802Ni63b405.RAD

<u>Contaminated Zone Dimensions</u>	<u>Initial Soil Concentrations, pCi/g</u>
Area: 10000.00 square meters	Ni-63 1.000E+00
Thickness: 2.85 meters	
Cover Depth: 0.15 meters	

Total Dose TDOSE(t), mrem/yr  
Basic Radiation Dose Limit = 1.000E+01 mrem/yr  
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.900E-01	2.000E-01	1.000E+00	7.100E+00	4.270E+01	1.300E+02	1.344E+02	1.500E+02	1.000E+03
TDOSE(t):	1.655E-06	2.283E-06	2.317E-06	4.948E-06	2.400E-05	1.048E-04	1.658E-04	1.659E-04	1.649E-04	4.036E-07
M(t):	1.655E-07	2.283E-07	2.317E-07	4.948E-07	2.400E-06	1.048E-05	1.658E-05	1.659E-05	1.649E-05	4.036E-08

Maximum TDOSE(t): 1.659E-04 mrem/yr at t = 134.4 ± 0.3 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 1.344E+02 years

Water Independent Pathways (Inhalation excludes radon)

	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Radio-Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	frac
Ni-63	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.00
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.00

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 1.344E+02 years

Water Dependent Pathways

	Water		Fish		Radon		Plant		Meat		Milk		All Pathways	
Radio-Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	frac
Ni-63	1.659E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.659E-04	1.00
Total	1.659E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.659E-04	1.00

\*Sum of all water independent and dependent pathways.

RESRAD, Version 6.1 T½ Limit = 0.5 year 09/24/2002 12:29 Page 8  
Summary : RESRAD Default Parameters File: deepsoil061802H3b405.RAD

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	10000.00 square meters	H-3	1.000E+00
Thickness:	2.85 meters		
Cover Depth:	0.15 meters		

Total Dose TDOSE(t), mrem/yr									
Basic Radiation Dose Limit = 1.000E+01 mrem/yr									
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)									
t (years):	0.000E+00	1.900E-01	2.000E-01	1.000E+00	7.100E+00	4.270E+01	1.340E+02	1.500E+02	1.000E+03
TDOSE(t):	1.241E-01	1.158E-01	1.146E-01	3.942E-02	1.005E-05	1.577E-28	0.000E+00	0.000E+00	0.000E+00
M(t):	1.241E-02	1.158E-02	1.146E-02	3.942E-03	1.005E-06	1.577E-29	0.000E+00	0.000E+00	0.000E+00

Maximum TDOSE(t): 1.241E-01 mrem/yr at t = 0.000E+00 years

RESRAD, Version 6.1 T<sub>1/2</sub> Limit = 0.5 year 09/24/2002 12:40 Page 7  
Concent : RESRAD Default Parameters File: deepsoil061802csb405.RAD

Concentration of radionuclides in environmental media  
at t = 4.270E+01 years

Radio- Nuclide	Contaminat- ed Zone	Surface Soil*	Air Par- ticulate	Well Water	Surface Water
	pCi/q	pCi/q	pCi/m**3	pCi/L	pCi/L
Cs-137	3.714E-01	1.057E-01	1.790E-06	9.020E-03	9.020E-05

\*The Surface Soil is the top layer of soil within the user specified mixing zone/depth.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

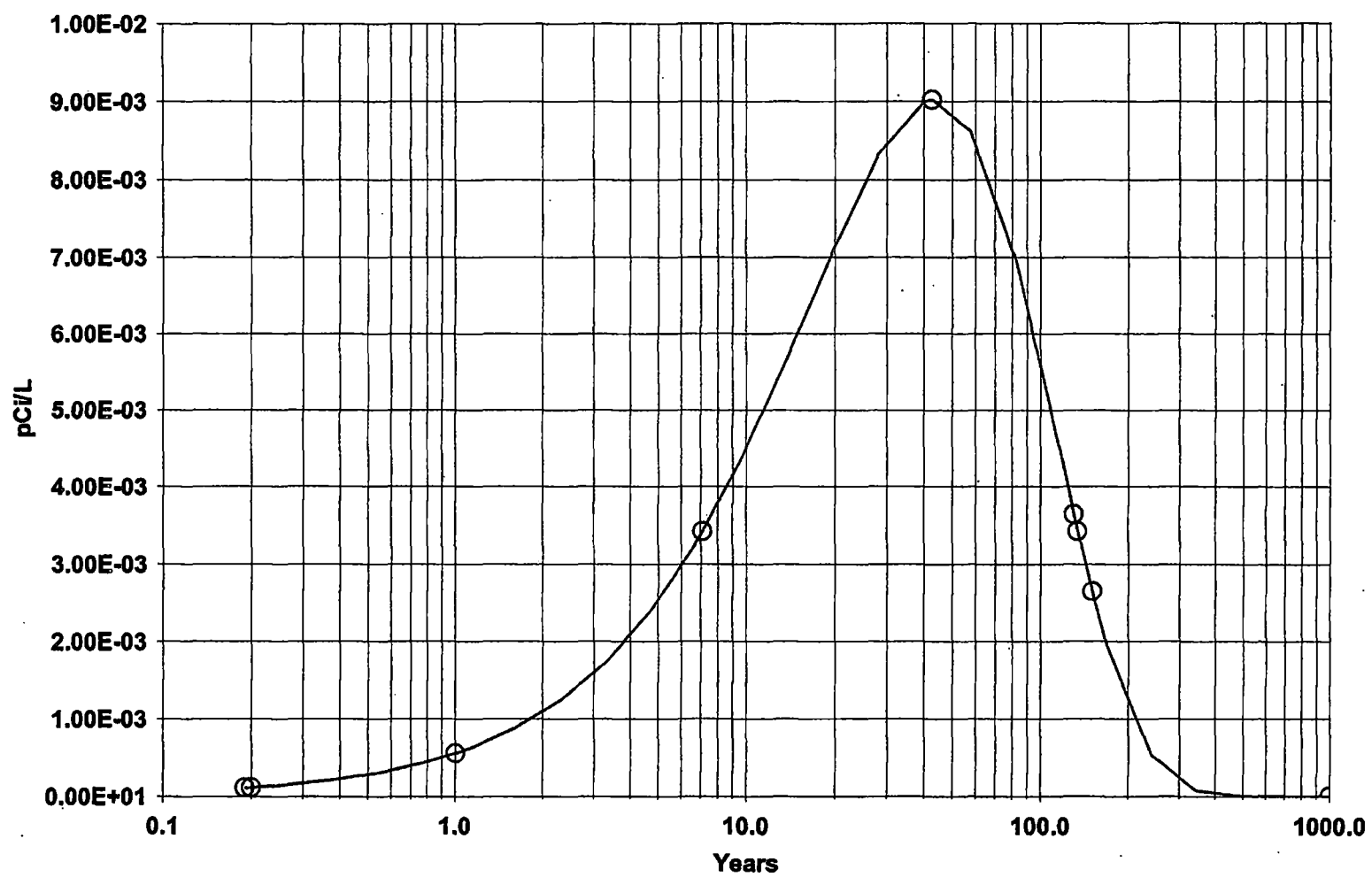
Concentration of radionuclides in foodstuff media  
at t = 4.270E+01 years\*

Radio- Nuclide	Drinking Water	Nonleafy Vegetable	Leafy Vegetable	Fodder Meat	Fodder Milk	Meat	Milk	Fish	Crustacea
	pCi/L	pCi/kq	pCi/kq	pCi/kq	pCi/kq	pCi/kq	pCi/L	pCi/kq	pCi/kq
Cs-137	9.020E-03	1.309E+01	1.310E+01	1.312E+01	1.310E+01	2.832E+01	6.198E+00	1.803E-01	9.016E-03

\*Concentrations are at consumption time and include radioactive decay and ingrowth during storage time.  
For livestock fodder, consumption time is t minus meat or milk storage time.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active..

**CONCENTRATION: Cs-137, Drinking Water**



RESRAD, Version 6.1 T<sub>1/2</sub> Limit = 0.5 year 09/24/2002 13:01 Page 6  
Concent : RESRAD Default Parameters File: deepsoil061802Cob405.RAD

Concentration of radionuclides in environmental media  
at t = 7.100E+00 years

Radio- Nuclide	Contaminat- ed Zone	Surface Soil*	Air Par- ticulate	Well Water	Surface Water
	pCi/q	pCi/q	pCi/m**3	pCi/L	pCi/L
Co-60	3.922E-01	1.856E-02	3.143E-07	2.244E-02	2.244E-04

\*The Surface Soil is the top layer of soil within the user specified mixing zone/depth.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

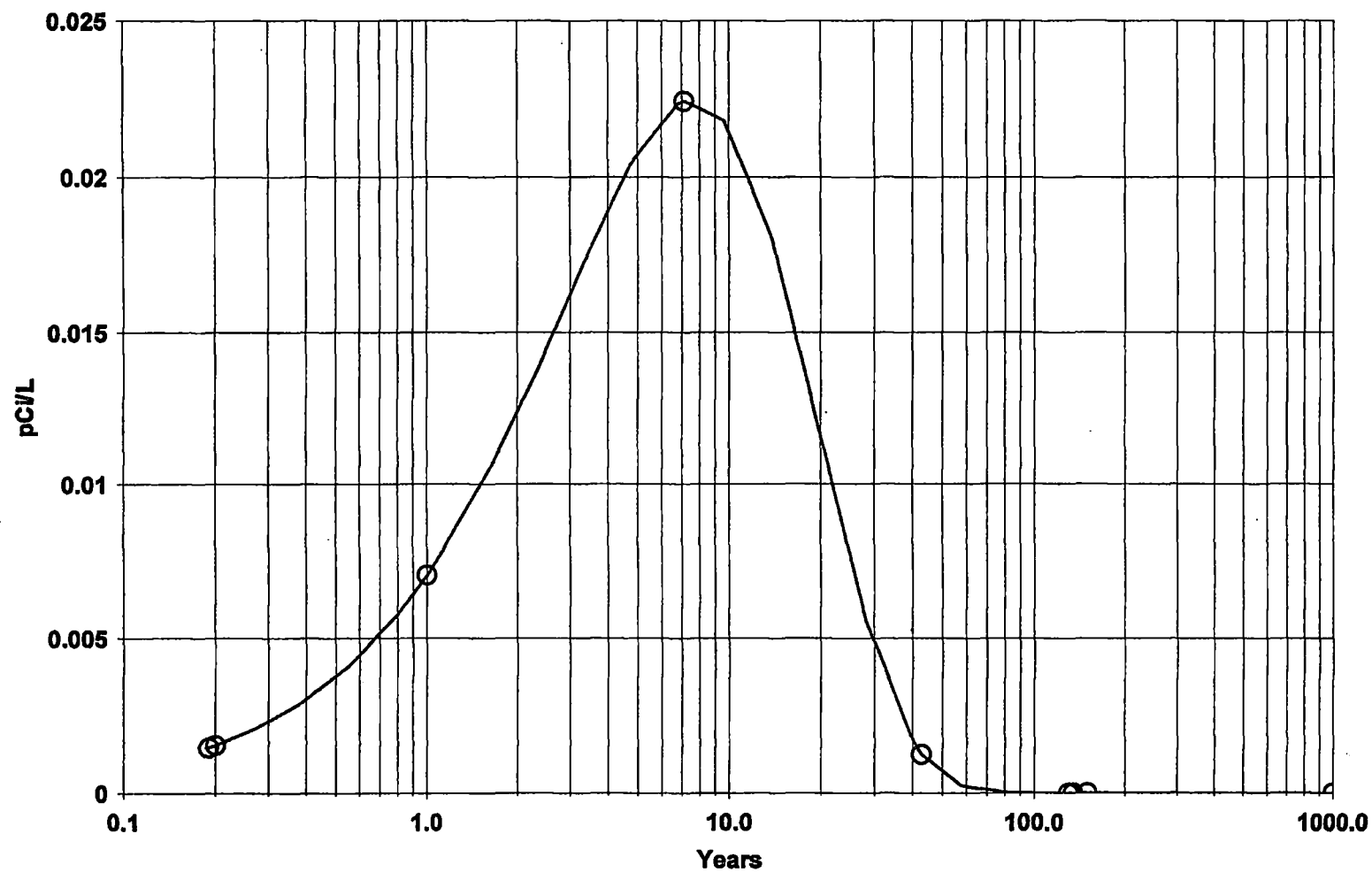
Concentration of radionuclides in foodstuff media  
at t = 7.100E+00 years\*

Radio- Nuclide	Drinking Water	Nonleafy Vegetable	Leafy Vegetable	Fodder Meat	Fodder Milk	Meat	Milk	Fish	Crustacea
	pCi/L	pCi/kg	pCi/kg	pCi/kg	pCi/kg	pCi/kg	pCi/L	pCi/kg	pCi/kg
Co-60	2.243E-02	2.640E+01	2.643E+01	2.662E+01	2.644E+01	3.615E+01	2.933E+00	6.712E-02	4.475E-02

\*Concentrations are at consumption time and include radioactive decay and ingrowth during storage time.  
For livestock fodder, consumption time is t minus meat or milk storage time.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

**CONCENTRATION: Co-60, Drinking Water**





RESRAD, Version 6.1 T<sub>1/2</sub> Limit = 0.5 year 09/24/2002 13:18 Page 9  
Concent : RESRAD Default Parameters File: deepsoil1061802Ni63b405.RAD

Concentration of radionuclides in environmental media  
at t = 1.344E+02 years

Radio- Nuclide	Contaminat- ed Zone	Surface Soil*	Air Par- ticulate	Well Water	Surface Water
	pCi/q	pCi/q	pCi/m**3	pCi/L	pCi/L
Ni-63	3.591E-01	3.218E-01	5.447E-06	6.008E-01	6.008E-03

\*The Surface Soil is the top layer of soil within the user specified mixing zone/depth.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

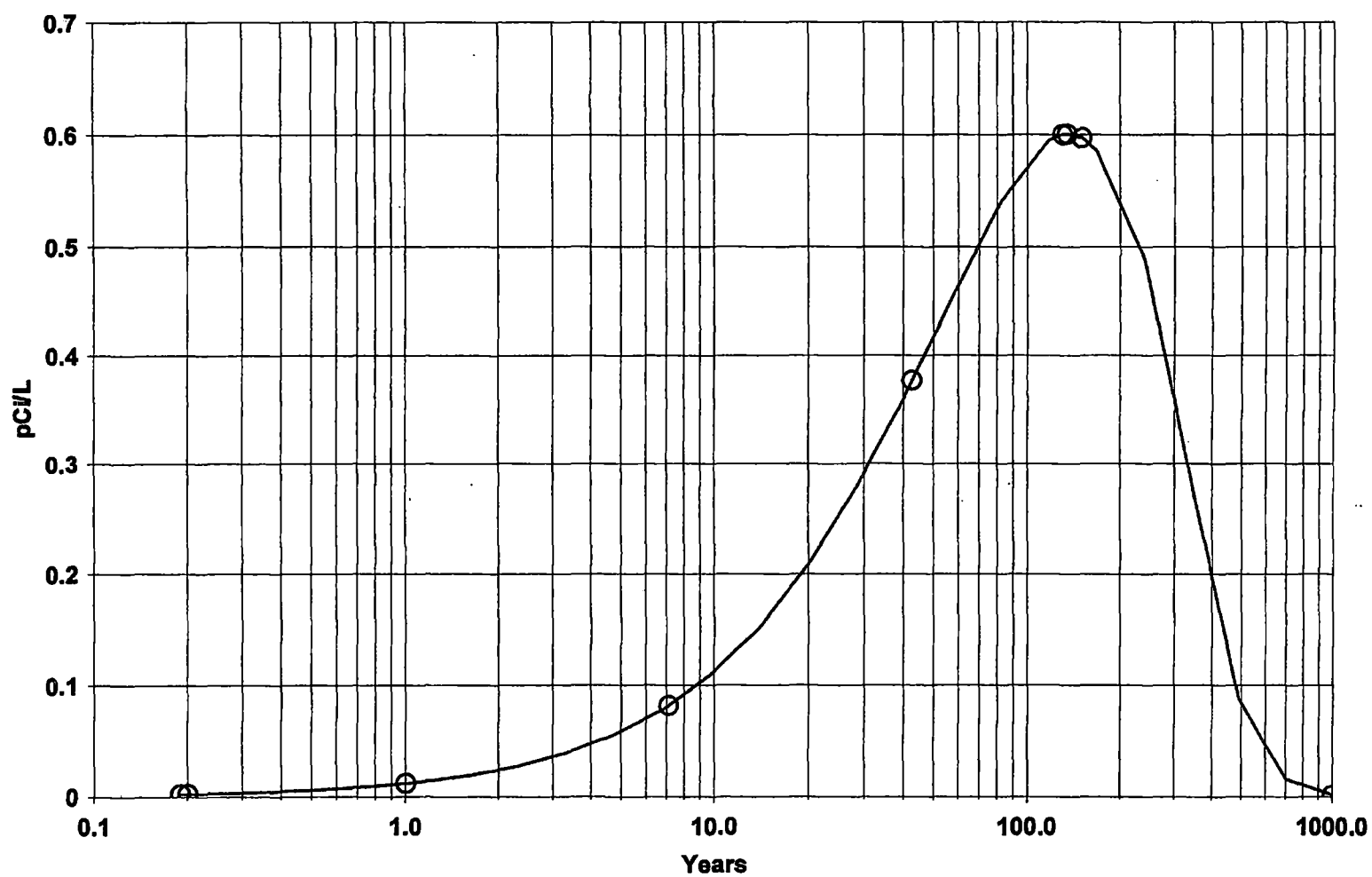
Concentration of radionuclides in foodstuff media  
at t = 1.344E+02 years\*

Radio- Nuclide	Drinking Water	Nonleafy Vegetable	Leafy Vegetable	Fodder Meat	Fodder Milk	Meat	Milk	Fish	Crustacea
	pCi/L	pCi/kq	pCi/kq	pCi/kq	pCi/kq	pCi/kq	pCi/L	pCi/kq	pCi/kq
Ni-63	6.008E-01	1.785E+01	1.864E+01	1.874E+01	1.873E+01	7.323E+00	2.575E+01	6.007E-01	6.007E-01

\*Concentrations are at consumption time and include radioactive decay and ingrowth during storage time.  
For livestock fodder, consumption time is t minus meat or milk storage time.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

**CONCENTRATION: Ni-63, Drinking Water**



Concentration of radionuclides in environmental media  
 at t = 2.000E-01 years

Radio- Nuclide	Contaminat- ed Zone	Surface Soil*	Air Par- ticulate	Well Water	Surface Water
	pCi/q	pCi/q	pCi/m**3	pCi/L	pCi/L
H-3	7.659E-01	1.021E-03	1.729E-08	6.770E+03	6.770E+01

\*The Surface Soil is the top layer of soil within the user specified mixing zone/depth.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Concentration of H-3 in soil moisture = 0.000E+00 pCi/ml  
 Concentration of gaseous H-3 in air = 0.000E+00 pCi/m\*\*3

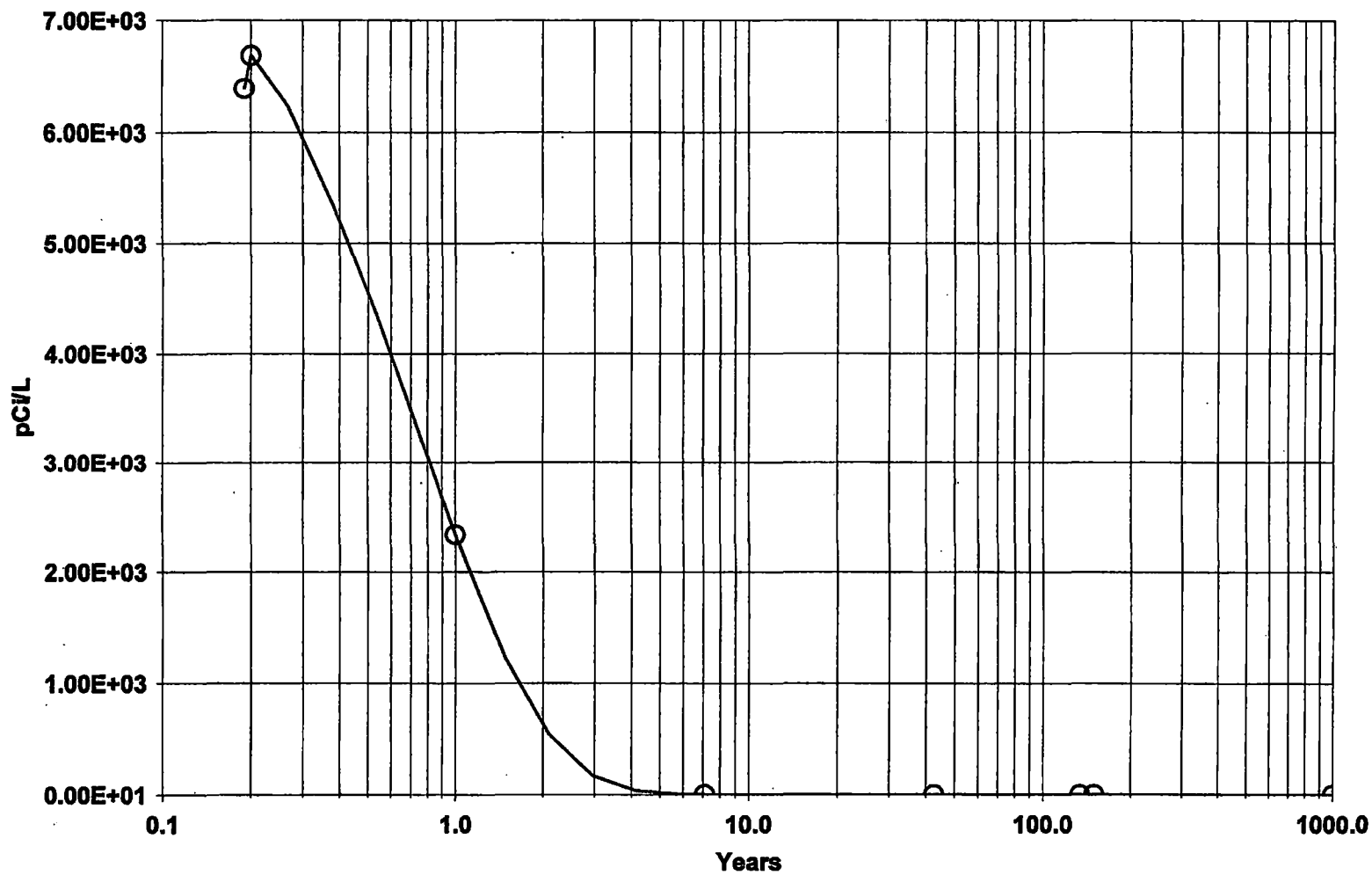
Concentration of radionuclides in foodstuff media  
 at t = 2.000E-01 years\*

Radio- Nuclide	Drinking Water	Nonleafy Vegetable	Leafy Vegetable	Fodder Meat	Fodder Milk	Meat	Milk	Fish	Crustacea
	pCi/L	pCi/kq	pCi/kq	pCi/kq	pCi/kq	pCi/kq	pCi/L	pCi/kq	pCi/kq
H-3	6.687E+03	8.966E+03	1.217E+04	5.295E+03	5.763E+03	3.497E+03	5.923E+03	6.186E+01	6.186E+01

\*Concentrations are at consumption time and include radioactive decay and ingrowth during storage time.  
 For livestock fodder, consumption time is t minus meat or milk storage time.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

**CONCENTRATION: H-3, Drinking Water**



**Attachment 6-10  
Buried Piping List and Projected Concentration Calculation**

Attachment 7, Table 1

Description of Buried Pipe/Conduit	Diam., In.	Length ft.	Surface Area, ft <sup>2</sup>	Surface Area, cm <sup>2</sup>	Surface Area, m <sup>2</sup>	Vol. ft <sup>3</sup>	Vol. cm <sup>3</sup>	Vol. m <sup>3</sup>
Turbine Hall to Sewage Treatment	12	208	847	8.0E+05	80	162	4.6E+06	4.6E+00
Staff Building to Basin West of MH 17	6	52	82	7.6E+04	8	15	2.9E+05	2.9E-01
Staff Building to Basin West of MH 17	10	43	113	1.0E+05	10	23	6.6E+05	6.6E-01
Staff Building to Basin West of MH 17	4	38	41	3.8E+04	4	3	9.6E+04	9.6E-02
Catch Basin West of MH 17 to MH 17	4	55	58	5.4E+04	5	5	1.4E+05	1.4E-01
MH 17 to MH 18	24	45	283	2.6E+05	26	141	4.0E+06	4.0E+00
MH 18 to MH 19	30	55	432	4.0E+05	40	270	7.6E+06	7.6E+00
MH 15 to Back River	30	170	1335	1.2E+06	124	634	2.4E+07	2.4E+01
Went to Catch Basin East of Staff	4	60	63	5.8E+04	6	5	1.3E+05	1.3E-01
Catch Basin W. of MH 17 to Catch Basin E. of Tunnel	4	75	79	7.3E+04	7	7	1.9E+05	1.9E-01
Catch Basin E. of Staff Tunnel to Catch Basin N. of MH 20	4	28	27	2.5E+04	3	2	6.4E+04	6.4E-02
Warehouse to Catch Basin E. of Staff Tunnel	4	515	539	5.0E+05	50	45	1.3E+06	1.3E+00
Temp Sewer N. of MH 20 to Sewage Treatment Plant	6	348	534	5.0E+05	50	67	1.9E+06	1.9E+00
Temp Sewer N. of MH 20 to Sewage Treatment Plant	8	348	712	6.6E+05	66	119	3.4E+06	3.4E+00
Went Roof Drain to MH 21	4	37	39	3.6E+04	4	3	9.1E+04	9.1E-02
MH 21 to MH 22	15	165	404	3.8E+05	38	126	3.6E+06	3.6E+00
Roof Drain by Road YH to 15" Pipe	10	65	170	1.6E+05	16	35	1.0E+06	1.0E+00
MH 22 to MH 23	18	155	730	6.8E+05	68	274	7.8E+06	7.8E+00
Basin North of TK-18 to MH 23	24	52	327	3.0E+05	30	165	4.6E+06	4.6E+00
MH 23 to MH 24	18	54	284	2.6E+05	26	98	2.8E+06	2.8E+00
MH 24 to MH 27	24	110	591	5.4E+05	54	346	8.8E+06	8.8E+00
Pine Pumphouse Drain to MH 38	4	28	27	2.5E+04	3	2	6.4E+04	6.4E-02
MH 38 to MH 255	10	88	225	2.1E+05	21	47	1.3E+06	1.3E+00
MH 255 to MH 256	12	95	296	2.8E+05	28	75	2.1E+06	2.1E+00
MH 256 to MH 26	12	60	186	1.8E+05	18	47	1.3E+06	1.3E+00
MH 26 to MH 27	15	145	573	5.3E+05	53	175	5.1E+06	5.1E+00
WH Bldg. Drain, MH 28 to MH 27	4	403	423	3.9E+05	39	35	1.0E+06	1.0E+00
MH 27 to MH 28	24	180	1184	1.1E+06	111	587	1.7E+07	1.7E+01
MH 28 to MH 29	24	148	517	5.6E+05	55	459	1.3E+07	1.3E+01
MH 29 to West Shoreline	30	50	393	3.6E+05	36	245	6.9E+06	6.9E+00
MH 20 to MH 19	12	133	418	3.9E+05	39	104	3.0E+06	3.0E+00
Roof Drain, NW Corner to MH 19	6	10	18	1.5E+04	1	2	5.6E+04	5.6E-02
MH 19 to MH 18	12	60	186	1.8E+05	18	47	1.3E+06	1.3E+00
Roof Drain, NE Corner to MH 18	6	19	30	2.8E+04	3	4	1.1E+05	1.1E-01
MH 18 to MH 6	12	110	346	3.2E+05	32	88	2.4E+06	2.4E+00
Roof Drain E Side of Turbine to MH 4	8	82	172	1.6E+05	16	28	8.1E+05	8.1E-01
MH 4 to MH 5	12	80	281	2.3E+05	23	63	1.8E+06	1.8E+00
MH 5 to Back River	15	200	785	7.3E+05	73	245	6.9E+06	6.9E+00
<b>Totals</b>		<b>4496</b>	<b>14015</b>	<b>1.3E+07</b>	<b>1302</b>	<b>5008</b>	<b>1.4E+08</b>	<b>1.4E+02</b>

Table 1 is a compilation of the piping and conduit that will remain underground and at depths greater than three feet.

The piping dimensions were provided by Maine Yankee Engineering. The Surface Area was calculated for pipes assuming that they are cylinders using the equation  $\pi \cdot D \cdot L$ , where  $\pi \cdot D$  is the circumference of the cylinder and  $L$  is the length. The area was converted to metric units,  $\text{cm}^2$  and  $\text{m}^2$ . The volume of the cylinder is determined using the equation  $\pi \cdot r^2 \cdot L$  and was also converted to metric units,  $\text{cm}^3$  and  $\text{m}^3$ .

In its approach to model actual or potential residual radiological constituents Maine Yankee developed unitized dose factors for buried piping and conduit by assuming a unit inventory of 1 dpm/100  $\text{cm}^2$  gross beta radioactivity was present on the internal surfaces. This allows a calculation that ratios the total available gross beta radioactivity to the total volume of the piping. So, if the total surface area of the buried piping is  $1.302 \text{ E}7 \text{ cm}^2$ , then the total gross beta radioactivity is  $1.302 \text{ E}5$  dpm:

$$1.302 \text{ E}7 \text{ cm}^2 \cdot 1 \text{ dpm}/100 \text{ cm}^2 = 1.302 \text{ E}5 \text{ dpm}$$

If this gross beta radioactivity is divided by the total volume ( $1.42 \text{ E}+08 \text{ cm}^3$ ), this results in a concentration of  $9.182 \text{ E}-4 \text{ dpm}/\text{cm}^3$ . Using density of  $1.6 \text{ g}/\text{cm}^3$ , and converting to pCi, we get a conversion factor of  $2.59 \text{ E}-4 \text{ pCi}/\text{g}$  per dpm/100  $\text{cm}^2$ . [ $9.182 \text{ E}-4 \text{ dpm}/\text{cm}^3 \cdot \text{cm}^3 / 1.6 \text{ g} \cdot \text{pCi}/2.22 \text{ dpm}$ ]. This factor is used in the Buried Pipe and Conduit Worksheet.

Section 6.7.1.c discusses drinking water and irrigation model input parameters-porosity, bulk density, annual drinking water and irrigation rates used in this assessment.

Direct dose conversion factors were determined using the computer code Microshield. The dimension that equated to a volume of soil displaced by the pipes,  $141.8 \text{ m}^3$ , was calculated for input, assuming that the thickness was one meter ( $h=1$ )-

$$\begin{aligned}\pi \cdot r^2 \cdot h &= \text{Volume} \\ \pi \cdot r^2 \cdot 1 &= 141.8 \text{ m}^3 \\ \pi \cdot r^2 &= 141.8 \text{ m}^2 \\ r^2 &= 45.14 \text{ m}^2 \\ r &= 6.71836 \text{ m}\end{aligned}$$

Source dimension having a radius of 671.8 cm and a thickness of 1 meter was used. The depth is assumed to be 1 meter below grade. Unit concentrations (e.g., 1 pCi/g  $^{60}\text{Co}$ ,  $^{57}\text{Co}$ , etc.) of radionuclides were input to Microshield along with a density of  $1.6 \text{ g}/\text{cm}^3$ . The ICRP 51 Deep Dose Equivalent Rate-Rotational was determined by the code. The result was multiplied by the DandD default outdoor occupancy time of 0.1101 years or 964 hours. The direct dose factors are listed in the following tables.

Nuclide	Microshield Deep Dose Equivalent Rate-Rotational mSv/h	mrem/hr	Hours/year	mrem/year
Cs-134	2.291E-10	2.291E-8	964	2.21E-05
Cs-137	4.121E-11	4.121E-9	964	3.97E-06
Co-60	2.624E-9	2.624E-7	964	2.53E-04
Co-57	9.789E-14	9.789E-12	964	9.44E-09



**Attachment 6-11  
Buried Piping RESRAD Output**

RESRAD, Version 6.1 T4 Limit = 0.5 year 09/24/2002 15:53 Page 1  
Summary : RESRAD Default Parameters File: buriedpipe092402N163b405.RAD

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*Buried piping,  
deep soil, water  
pathway only, site ks  
values, Greber  
adjustments -*

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Summary : RESRAD Default Parameters File: buriedpipe092402N163b405.RAD

Dose Conversion Factor (and Related) Parameter Summary  
File: FGR 13 Morbidity

Menu	Parameter	Current Value	Default	Parameter Name
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Ni-63	6.290E-06	6.290E-06	DCF2( 1)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Ni-63	5.770E-07	5.770E-07	DCF3( 1)
D-34	Food transfer factors:			
D-34	Ni-63 , plant/soil concentration ratio, dimensionless	5.000E-02	5.000E-02	RTF( 1,1)
D-34	Ni-63 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	5.000E-03	5.000E-03	RTF( 1,2)
D-34	Ni-63 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-02	2.000E-02	RTF( 1,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Ni-63 , fish	1.000E+02	1.000E+02	BIOFAC( 1,1)
D-5	Ni-63 , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC( 1,2)

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Summary: RESRAD Default Parameters File: buriedpipe092402N163b405.RAD

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	1.420E+02	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	1.000E+00	2.000E+00	---	THICKO
R011	Length parallel to aquifer flow (m)	1.000E+02	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	1.000E+01	2.500E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.900E-01	1.000E+00	---	T( 2)
R011	Times for calculations (yr)	2.000E-01	3.000E+00	---	T( 3)
R011	Times for calculations (yr)	1.000E+00	1.000E+01	---	T( 4)
R011	Times for calculations (yr)	7.100E+00	3.000E+01	---	T( 5)
R011	Times for calculations (yr)	4.270E+01	1.000E+02	---	T( 6)
R011	Times for calculations (yr)	1.300E+02	3.000E+02	---	T( 7)
R011	Times for calculations (yr)	1.344E+02	1.000E+03	---	T( 8)
R011	Times for calculations (yr)	1.500E+02	0.000E+00	---	T( 9)
R011	Times for calculations (yr)	1.000E+03	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Ni-63	1.000E+00	0.000E+00	---	S1( 1)
R012	Concentration in groundwater (pCi/L): Ni-63	not used	0.000E+00	---	W1( 1)
R013	Cover depth (m)	1.500E-01	0.000E+00	---	COVERO
R013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.600E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	3.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	3.200E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	4.050E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.000E+00	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.000E+06	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	1.600E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	3.000E-01	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	1.000E-02	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	2.000E-01	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	3.200E+01	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	2.000E-02	2.000E-02	---	HGWT
R014	Saturated zone b parameter	4.050E+00	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	1.000E-03	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	1.000E+01	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	not used	2.500E+02	---	UW
R015	Number of unsaturated zone strata	1	1	---	NS

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Summary : RESRAD Default Parameters File: buriedpipe092402N163b405.RAD

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R015	Unsat. zone 1, thickness (m)	0.000E+00	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	1.600E+00	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	3.000E-01	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	2.000E-01	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	2.000E-01	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	5.300E+00	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	1.000E+03	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Ni-63				
R016	Contaminated zone (cm**3/g)	2.740E+02	1.000E+03	---	DCNUCC( 1)
R016	Unsaturated zone 1 (cm**3/g)	2.740E+02	1.000E+03	---	DCNUCU( 1,1)
R016	Saturated zone (cm**3/g)	2.740E+02	1.000E+03	---	DCNUCS( 1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.140E-03	ALEACH( 1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK( 1)
R017	Inhalation rate (m**3/yr)	not used	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	not used	1.000E-04	---	MLINH
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	not used	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	not used	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	not used	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	not used	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	not used	1.000E+00	>0 shows circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE( 1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE( 2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE( 3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE( 4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE( 5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE( 6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE( 7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE( 8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE( 9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA( 1)
R017	Ring 2	not used	2.732E-01	---	FRACA( 2)
R017	Ring 3	not used	0.000E+00	---	FRACA( 3)
R017	Ring 4	not used	0.000E+00	---	FRACA( 4)
R017	Ring 5	not used	0.000E+00	---	FRACA( 5)
R017	Ring 6	not used	0.000E+00	---	FRACA( 6)
R017	Ring 7	not used	0.000E+00	---	FRACA( 7)
R017	Ring 8	not used	0.000E+00	---	FRACA( 8)
R017	Ring 9	not used	0.000E+00	---	FRACA( 9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)

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Summary : RESRAD Default Parameters File: buriedpipe092402N163b405.RAD

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R018	Fruits, vegetables and grain consumption (kg/yr)	not used	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	not used	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	not used	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	not used	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	not used	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	not used	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	not used	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	4.780E+02	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	1.000E+00	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	not used	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	not used	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	not used	5.000E-01	---	FR9
R018	Contamination fraction of plant food	not used	-1	---	FPLANT
R018	Contamination fraction of meat	not used	-1	---	FMEAT
R018	Contamination fraction of milk	not used	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	not used	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	not used	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	not used	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	not used	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	not used	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	not used	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	not used	1.500E-01	---	DM
R019	Depth of roots (m)	not used	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	1.000E+00	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	not used	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	not used	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	not used	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	not used	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	not used	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	not used	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	not used	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	not used	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	not used	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	not used	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	not used	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	not used	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR

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## Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
C14	DCF correction factor for gaseous forms of C14	not used	8.894E+01	---	CO2F
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

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Summary : RESRAD Default Parameters File: buriedpipe092402N163b405.RAD

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	suppressed
2 -- inhalation (w/o radon)	suppressed
3 -- plant ingestion	suppressed
4 -- meat ingestion	suppressed
5 -- milk ingestion	suppressed
6 -- aquatic foods	suppressed
7 -- drinking water	active
8 -- soil ingestion	suppressed
9 -- radon	suppressed
Find peak pathway doses	active



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Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	142.00 square meters	Ni-63	1.000E+00
Thickness:	1.00 meters		
Cover Depth:	0.15 meters		

Total Dose TDOSE(t), mrem/yr  
Basic Radiation Dose Limit = 1.000E+01 mrem/yr  
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.900E-01	2.000E-01	1.000E+00	7.100E+00	4.270E+01	1.300E+02	1.344E+02	1.500E+02	1.000E+03
TDOSE(t):	6.007E-08	8.290E-08	8.410E-08	1.796E-07	8.693E-07	3.749E-06	5.749E-06	5.744E-06	5.677E-06	3.484E-09
M(t):	6.007E-09	8.290E-09	8.410E-09	1.796E-08	8.693E-08	3.749E-07	5.749E-07	5.744E-07	5.677E-07	3.484E-10

Maximum TDOSE(t): 5.750E-06 mrem/yr at t = 128.3 ± 0.3 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 1.283E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ni-63	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 1.283E+02 years

Water Dependent Pathways

Radio- Nuclide Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ni-63	5.750E-06	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.750E-06	1.0000
Total	5.750E-06	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.750E-06	1.0000

\*Sum of all water independent and dependent pathways.

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Summary : RESRAD Default Parameters File: buriedpipe092402N163b405.RAD

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ni-63	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

Radio- Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ni-63	6.007E-08	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.007E-08	1.0000
Total	6.007E-08	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.007E-08	1.0000

\*Sum of all water independent and dependent pathways.

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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 1.900E-01 years

Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ni-63	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 1.900E-01 years

Water Dependent Pathways

Radio- Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ni-63	8.290E-08	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.290E-08	1.0000
Total	8.290E-08	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.290E-08	1.0000

\*Sum of all water independent and dependent pathways.

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Summary : RESRAD Default Parameters File: buriedpipe092402N163b405.RAD

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 2.000E-01 years

Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ni-63	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 2.000E-01 years

Water Dependent Pathways

Radio- Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ni-63	8.410E-08	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.410E-08	1.0000
Total	8.410E-08	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.410E-08	1.0000

\*Sum of all water independent and dependent pathways.

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Summary : RESRAD Default Parameters File: buriedpipe092402Ni63b405.RAD

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ni-63	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Dependent Pathways

Radio- Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ni-63	1.796E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.796E-07	1.0000
Total	1.796E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.796E-07	1.0000

\*Sum of all water independent and dependent pathways.

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Summary : RESRAD Default Parameters File: buriedpipe092402N163b405.RAD

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 7.100E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ni-63	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 7.100E+00 years

Water Dependent Pathways

Radio- Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ni-63	8.693E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.693E-07	1.0000
Total	8.693E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.693E-07	1.0000

\*Sum of all water independent and dependent pathways.

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Summary : RESRAD Default Parameters File: buriedpipe092402N163b405.RAD

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 4.270E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ni-63	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 4.270E+01 years

Water Dependent Pathways

Radio- Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ni-63	3.749E-06	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.749E-06	1.0000
Total	3.749E-06	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.749E-06	1.0000

\*Sum of all water independent and dependent pathways.

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Summary : RESRAD Default Parameters File: buriedpipe092402N163b405.RAD

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 1.300E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ni-63	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 1.300E+02 years

Water Dependent Pathways

Radio- Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ni-63	5.749E-06	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.749E-06	1.0000
Total	5.749E-06	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.749E-06	1.0000

\*Sum of all water independent and dependent pathways.



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Summary : RESRAD Default Parameters File: buriedpipe092402N163b405.RAD

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 1.344E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ni-63	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 1.344E+02 years

Water Dependent Pathways

Radio- Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ni-63	5.744E-06	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.744E-06	1.0000
Total	5.744E-06	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.744E-06	1.0000

\*Sum of all water independent and dependent pathways.

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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 1.500E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ni-63	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 1.500E+02 years

Water Dependent Pathways

Radio- Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ni-63	5.677E-06	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.677E-06	1.0000
Total	5.677E-06	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.677E-06	1.0000

\*Sum of all water independent and dependent pathways.

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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ni-63	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Dependent Pathways

Radio- Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ni-63	3.484E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.484E-09	1.0000
Total	3.484E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.484E-09	1.0000

\*Sum of all water independent and dependent pathways.

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Dose/Source Ratios Summed Over All Pathways  
Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Branch Fraction*	t=	0.000E+00	1.900E-01	2.000E-01	1.000E+00	7.100E+00	4.270E+01	1.300E+02	1.344E+02	1.500E+02	1.000E+03
Ni-63	Ni-63	1.000E+00		6.007E-08	8.290E-08	8.410E-08	1.796E-07	8.693E-07	3.749E-06	5.749E-06	5.744E-06	5.677E-06	3.484E-09

\*Branch Fraction is the cumulative factor for the j't principal radionuclide daughter: CUMBRF(j) = BRF(1)\*BRF(2)\* ... BRF(j).  
The DSR includes contributions from associated (half-life ≤ 0.5 yr) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g  
Basic Radiation Dose Limit = 1.000E+01 mrem/yr

Nuclide (i)	t=	0.000E+00	1.900E-01	2.000E-01	1.000E+00	7.100E+00	4.270E+01	1.300E+02	1.344E+02	1.500E+02	1.000E+03
Ni-63		1.665E+08	1.206E+08	1.189E+08	5.569E+07	1.150E+07	2.668E+06	1.739E+06	1.741E+06	1.761E+06	2.871E+09

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)  
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g  
at t<sub>min</sub> = time of minimum single radionuclide soil guideline  
and at t<sub>max</sub> = time of maximum total dose = 128.3 ± 0.3 years

Nuclide (i)	Initial (pCi/g)	t <sub>min</sub> (years)	DSR(i,t <sub>min</sub> )	G(i,t <sub>min</sub> ) (pCi/g)	DSR(i,t <sub>max</sub> )	G(i,t <sub>max</sub> ) (pCi/g)
Ni-63	1.000E+00	128.3 ± 0.3	5.750E-06	1.739E+06	5.750E-06	1.739E+06

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Summary : RESRAD Default Parameters File: buriedpipe092402Ni63b405.RAD

Individual Nuclide Dose Summed Over All Pathways  
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	BRF(i)	DOSE(j,t), mrem/yr										
			t=	0.000E+00	1.900E-01	2.000E-01	1.000E+00	7.100E+00	4.270E+01	1.300E+02	1.344E+02	1.500E+02	1.000E+03
Ni-63	Ni-63	1.000E+00		6.007E-08	8.290E-08	8.410E-08	1.796E-07	8.693E-07	3.749E-06	5.749E-06	5.744E-06	5.677E-06	3.484E-09

BRF(i) is the branch fraction of the parent nuclide.

Individual Nuclide Soil Concentration  
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	BRF(i)	S(j,t), pCi/g										
			t=	0.000E+00	1.900E-01	2.000E-01	1.000E+00	7.100E+00	4.270E+01	1.300E+02	1.344E+02	1.500E+02	1.000E+03
Ni-63	Ni-63	1.000E+00		1.000E+00	9.984E-01	9.983E-01	9.917E-01	9.424E-01	6.998E-01	3.373E-01	3.251E-01	2.854E-01	2.340E-04

BRF(i) is the branch fraction of the parent nuclide.

RESRAD.EXE execution time = 0.55 seconds

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Part IV: Concentration of Radionuclides

Concentration of radionuclides in different media		
Time= 0.000E+00 .....		2
Time= 1.900E-01 .....		3
Time= 2.000E-01 .....		4
Time= 1.000E+00 .....		5
Time= 7.100E+00 .....		6
Time= 4.270E+01 .....		7
Time= 1.300E+02 .....		8
Time= 1.344E+02 .....		9
Time= 1.500E+02 .....		10
Time= 1.000E+03 .....		11

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Concent : RESRAD Default Parameters File: buriedpipe092402Ni63b405.RAD

Concentration of radionuclides in environmental media  
at t = 1.300E+02 years

Radio- Nuclide	Contaminat- ed Zone	Surface Soil*	Air Par- ticulate	Well Water	Surface Water
	pCi/q	pCi/q	pCi/m**3	pCi/L	pCi/L
Ni-63	3.373E-01	2.923E-01	3.171E-06	2.085E-02	8.143E-05

\*The Surface Soil is the top layer of soil within the user specified mixing zone/depth.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Concentration of radionuclides in foodstuff media  
at t = 1.300E+02 years\*

Radio- Nuclide	Drinking Water	Nonleafy Vegetable	Leafy Vegetable	Fodder Meat	Fodder Milk	Meat	Milk	Fish	Crustacea
	pCi/L	pCi/kq	pCi/kq	pCi/kq	pCi/kq	pCi/kq	pCi/L	pCi/kq	pCi/kq
Ni-63	2.085E-02	1.650E+01	1.652E+01	1.653E+01	1.653E+01	6.355E+00	2.117E+01	8.142E-03	8.142E-03

\*Concentrations are at consumption time and include radioactive decay and ingrowth during storage time.  
For livestock fodder, consumption time is t minus meat or milk storage time.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

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Concent : RESRAD Default Parameters File: buriedpipe092402C057b405.RAD

Concentration of radionuclides in environmental media  
at t = 1.000E+00 years

Radio- Nuclide	Contaminat- ed Zone	Surface Soil*	Air Par- ticulate	Well Water	Surface Water
	pCi/q	pCi/q	pCi/m**3	pCi/L	pCi/L
Co-57	3.924E-01	2.616E-03	2.838E-08	1.148E-04	4.486E-07

\*The Surface Soil is the top layer of soil within the user specified mixing zone/depth.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Concentration of radionuclides in foodstuff media  
at t = 1.000E+00 years\*

Radio- Nuclide	Drinking Water	Nonleafy Vegetable	Leafy Vegetable	Fodder Meat	Fodder Milk	Meat	Milk	Fish	Crustacea
	pCi/L	pCi/kq	pCi/kq	pCi/kq	pCi/kq	pCi/kq	pCi/L	pCi/kq	pCi/kq
Co-57	1.145E-04	2.620E+01	2.620E+01	2.757E+01	2.626E+01	3.565E+01	2.884E+00	1.319E-04	8.793E-05

\*Concentrations are at consumption time and include radioactive decay and ingrowth during storage time.  
For livestock fodder, consumption time is t minus meat or milk storage time.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.



Concentration of radionuclides in environmental media  
 at t = 7.100E+00 years

Radio- Nuclide	Contaminat- ed Zone	Surface Soil*	Air Par- ticulate	Well Water	Surface Water
	pCi/q	pCi/q	pCi/m**3	pCi/L	pCi/L
Co-60	3.905E-01	1.848E-02	2.005E-07	8.139E-04	3.179E-06

\*The Surface Soil is the top layer of soil within the user specified mixing zone/depth.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Concentration of radionuclides in foodstuff media  
 at t = 7.100E+00 years\*

Radio- Nuclide	Drinking Water	Nonleafy Vegetable	Leafy Vegetable	Fodder Meat	Fodder Milk	Meat	Milk	Fish	Crustacea
	pCi/L	pCi/kg	pCi/kg	pCi/kg	pCi/kg	pCi/kg	pCi/L	pCi/kg	pCi/kg
Co-60	8.136E-04	2.628E+01	2.628E+01	2.647E+01	2.629E+01	3.593E+01	2.910E+00	9.511E-04	6.341E-04

\*Concentrations are at consumption time and include radioactive decay and ingrowth during storage time.  
 For livestock fodder, consumption time is t minus meat or milk storage time.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Concentration of radionuclides in environmental media  
 at t = 1.000E+00 years

Radio- Nuclide	Contaminat- ed Zone	Surface Soil*	Air Par- ticulate	Well Water	Surface Water
	pCi/q	pCi/q	pCi/m**3	pCi/L	pCi/L
Cs-134	7.143E-01	4.762E-03	5.166E-08	1.474E-05	5.758E-08

\*The Surface Soil is the top layer of soil within the user specified mixing zone/depth.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Concentration of radionuclides in foodstuff media  
 at t = 1.000E+00 years\*

Radio- Nuclide	Drinking Water	Nonleafy Vegetable	Leafy Vegetable	Fodder Meat	Fodder Milk	Meat	Milk	Fish	Crustacea
	pCi/L	pCi/kg	pCi/kg	pCi/kg	pCi/kg	pCi/kg	pCi/L	pCi/kg	pCi/kg
Cs-134	1.469E-05	2.384E+01	2.384E+01	2.428E+01	2.386E+01	4.870E+01	1.051E+01	1.126E-04	5.631E-06

\*Concentrations are at consumption time and include radioactive decay and ingrowth during storage time.  
 For livestock fodder, consumption time is t minus meat or milk storage time.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Concentration of radionuclides in environmental media  
 at t = 4.270E+01 years

Radio- Nuclide	Contaminat- ed Zone	Surface Soil*	Air Par- ticulate	Well Water	Surface Water
	pCi/q	pCi/q	pCi/m**3	pCi/L	pCi/L
Cs-137	3.687E-01	1.050E-01	1.139E-06	3.269E-04	1.277E-06

\*The Surface Soil is the top layer of soil within the user specified mixing zone/depth.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Concentration of radionuclides in foodstuff media  
 at t = 4.270E+01 years\*

Radio- Nuclide	Drinking Water	Nonleafy Vegetable	Leafy Vegetable	Fodder Meat	Fodder Milk	Meat	Milk	Fish	Crustacea
	pCi/L	pCi/kg	pCi/kg	pCi/kg	pCi/kg	pCi/kg	pCi/L	pCi/kg	pCi/kg
Cs-137	3.269E-04	1.299E+01	1.299E+01	1.301E+01	1.299E+01	2.807E+01	6.136E+00	2.552E-03	1.276E-04

\*Concentrations are at consumption time and include radioactive decay and ingrowth during storage time.  
 For livestock fodder, consumption time is t minus meat or milk storage time.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Concentration of radionuclides in environmental media  
 at t = 1.000E+00 years

Radio- Nuclide	Contaminat- ed Zone	Surface Soil*	Air Par- ticulate	Well Water	Surface Water
	pCi/q	pCi/q	pCi/m**3	pCi/L	pCi/L
Fe-55	7.729E-01	5.152E-03	5.589E-08	2.262E-04	8.836E-07

\*The Surface Soil is the top layer of soil within the user specified mixing zone/depth.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Concentration of radionuclides in foodstuff media  
 at t = 1.000E+00 years\*

Radio- Nuclide	Drinking Water	Nonleafy Vegetable	Leafy Vegetable	Fodder Meat	Fodder Milk	Meat	Milk	Fish	Crustacea
	pCi/L	pCi/kg	pCi/kg	pCi/kg	pCi/kg	pCi/kg	pCi/L	pCi/kg	pCi/kg
Fe-55	2.256E-04	6.450E-01	6.453E-01	6.543E-01	6.457E-01	9.264E-01	1.143E-02	1.732E-04	2.771E-03

\*Concentrations are at consumption time and include radioactive decay and ingrowth during storage time.  
 For livestock fodder, consumption time is t minus meat or milk storage time.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Concentration of radionuclides in environmental media  
 at t = 1.900E-01 years

Radio- Nuclide	Contaminat- ed Zone	Surface Soil*	Air Par- ticulate	Well Water	Surface Water
	pCi/q	pCi/q	pCi/m**3	pCi/L	pCi/L
H-3	4.955E-01	6.276E-04	6.808E-09	1.914E+02	7.476E-01

\*The Surface Soil is the top layer of soil within the user specified mixing zone/depth.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Concentration of H-3 in soil moisture = 0.000E+00 pCi/ml  
 Concentration of gaseous H-3 in air = 0.000E+00 pCi/m\*\*3

Concentration of radionuclides in foodstuff media  
 at t = 1.900E-01 years\*

Radio- Nuclide	Drinking Water	Nonleafy Vegetable	Leafy Vegetable	Fodder Meat	Fodder Milk	Meat	Milk	Fish	Crustacea
	pCi/L	pCi/kg	pCi/kg	pCi/kg	pCi/kg	pCi/kg	pCi/L	pCi/kg	pCi/kg
H-3	1.893E+02	3.072E+03	2.781E+03	4.916E+03	4.080E+03	1.956E+03	1.097E+03	6.915E-01	6.915E-01

\*Concentrations are at consumption time and include radioactive decay and ingrowth during storage time.  
 For livestock fodder, consumption time is t minus meat or milk storage time.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Concentration of radionuclides in environmental media  
 at t = 4.000E+01 years

Radio- Nuclide	Contaminat- ed Zone	Surface Soil*	Air Par- ticulate	Well Water	Surface Water
	pCi/q	pCi/q	pCi/m**3	pCi/L	pCi/L
Sr-90	3.555E-01	9.479E-02	1.028E-06	2.147E-02	8.389E-05

\*The Surface Soil is the top layer of soil within the user specified mixing zone/depth.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

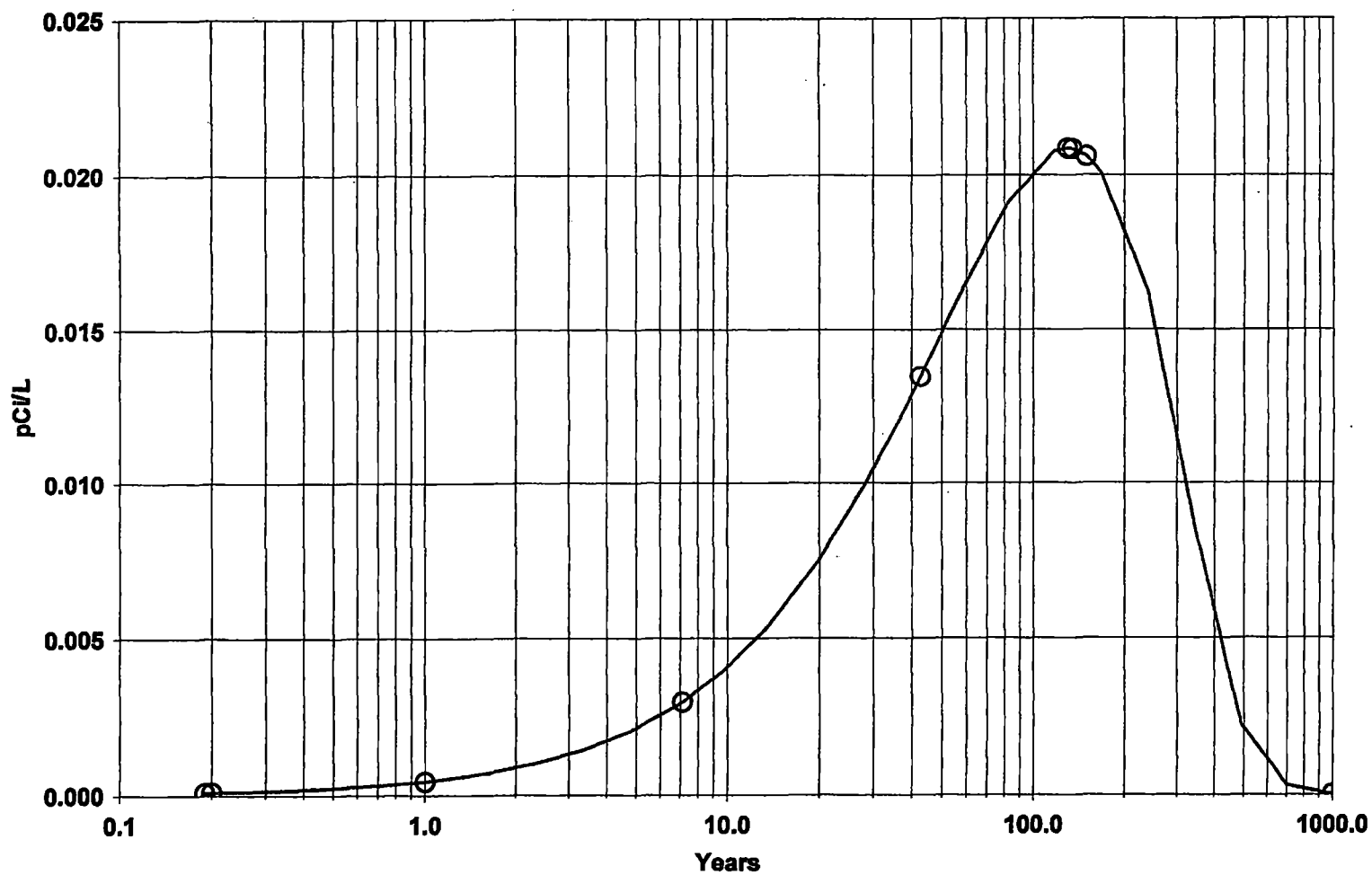
Concentration of radionuclides in foodstuff media  
 at t = 4.000E+01 years\*

Radio- Nuclide	Drinking Water	Nonleafy Vegetable	Leafy Vegetable	Fodder Meat	Fodder Milk	Meat	Milk	Fish	Crustacea
	pCi/L	pCi/kq	pCi/kq	pCi/kq	pCi/kq	pCi/kq	pCi/L	pCi/kq	pCi/kq
Sr-90	2.147E-02	9.362E+01	9.365E+01	9.378E+01	9.366E+01	5.134E+01	1.040E+01	5.031E-03	8.385E-03

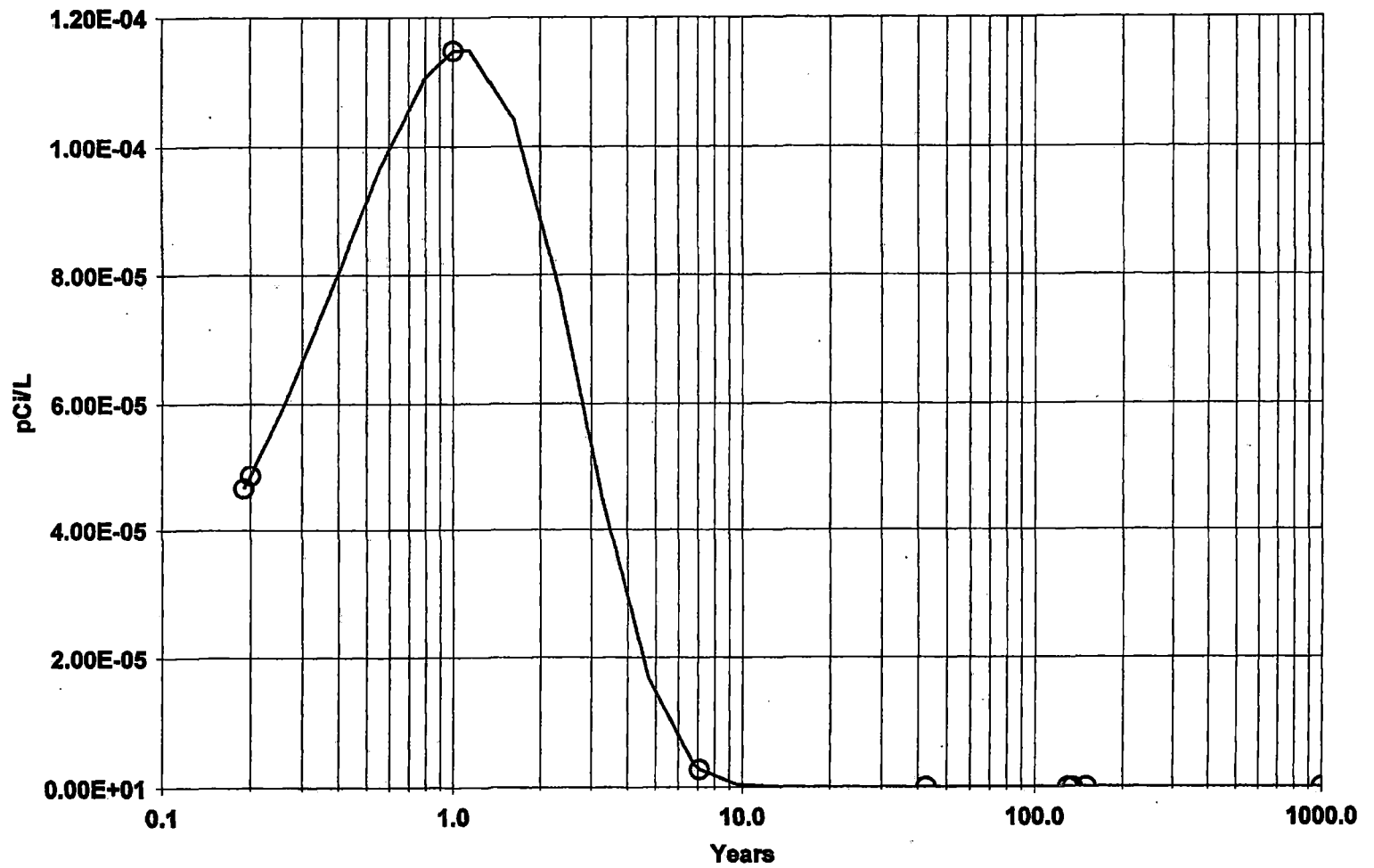
\*Concentrations are at consumption time and include radioactive decay and ingrowth during storage time.  
 For livestock fodder, consumption time is t minus meat or milk storage time.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

**CONCENTRATION: Ni-63, Well Water**

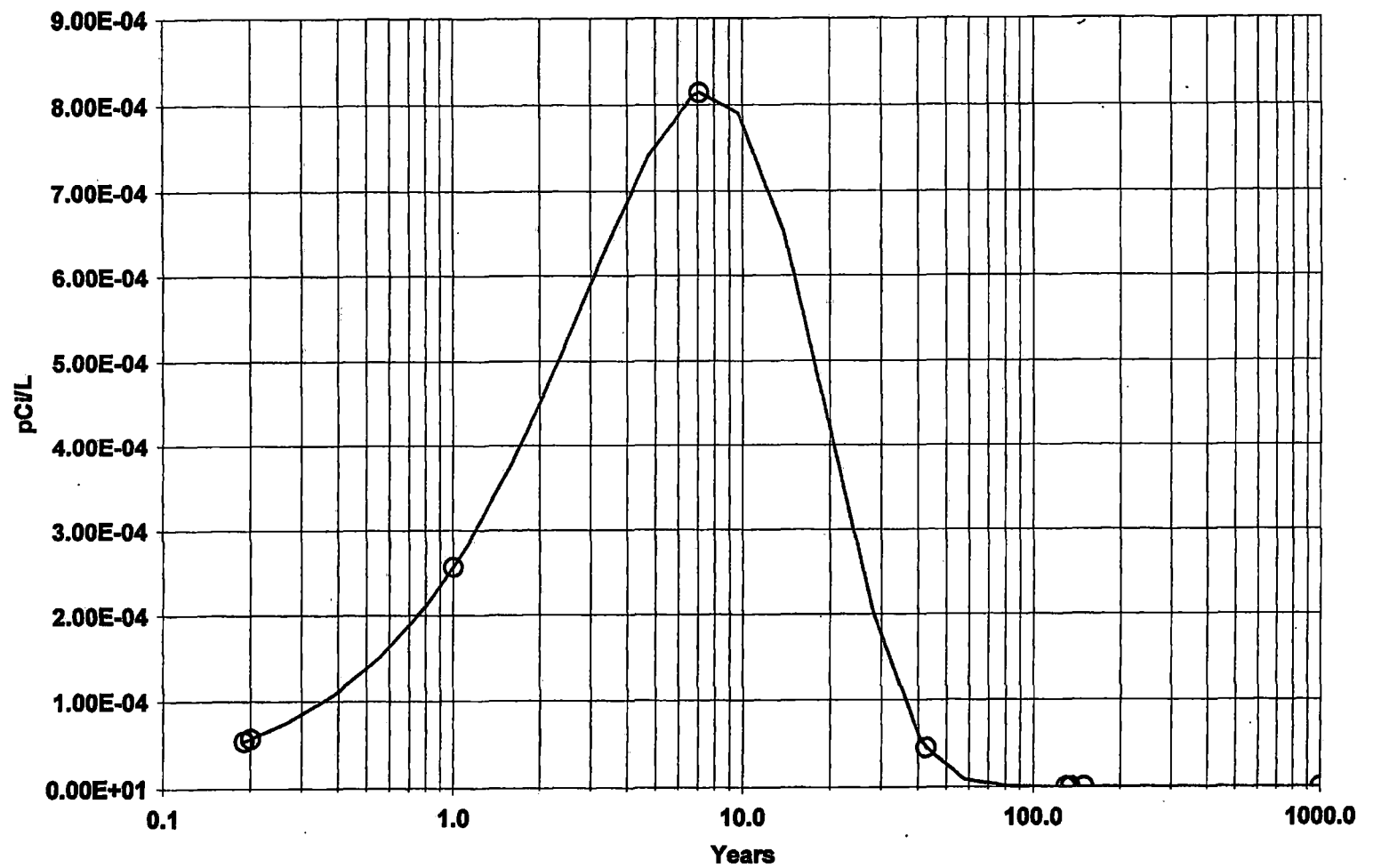


**CONCENTRATION: Co-57, Well Water**

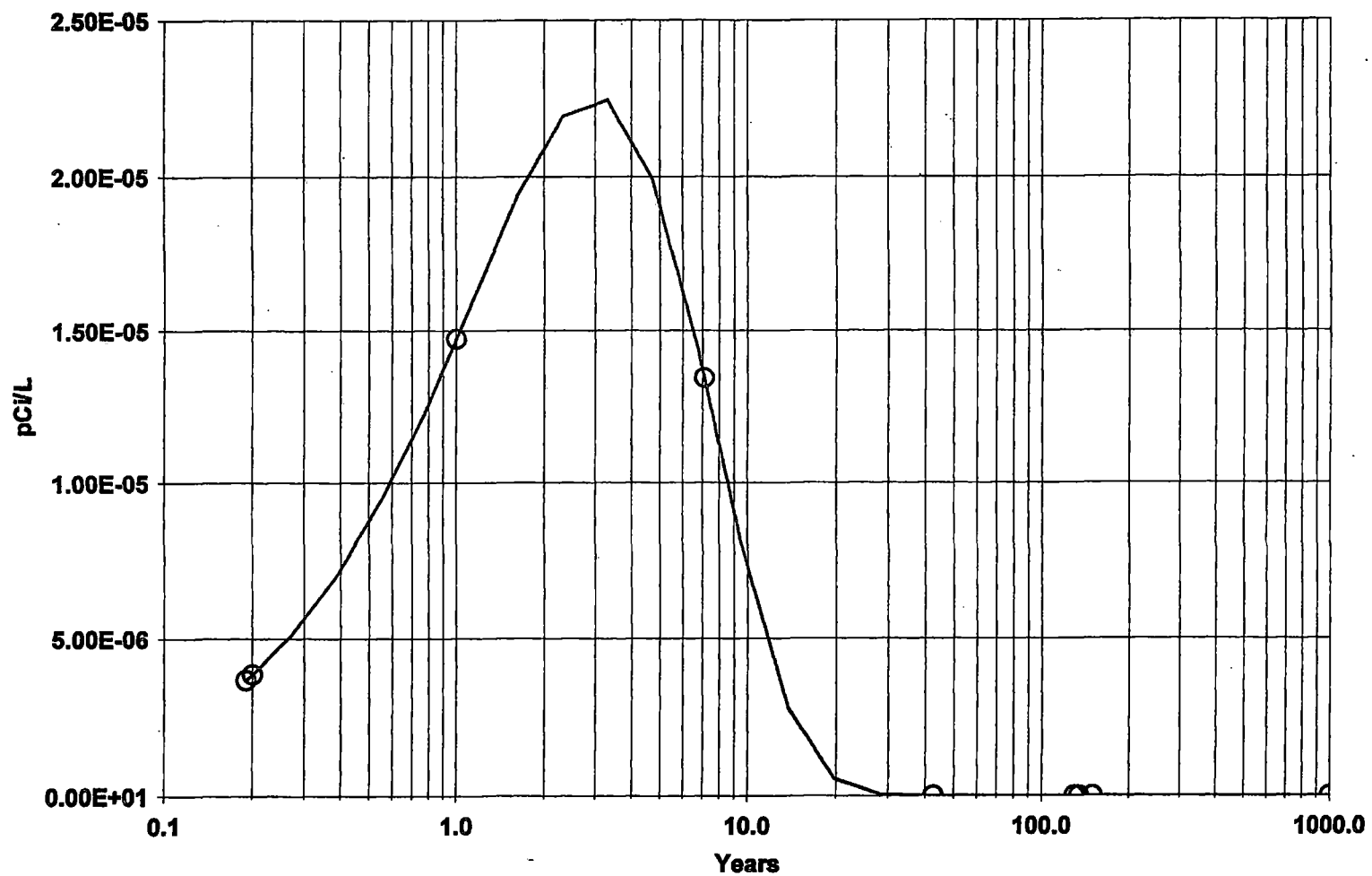




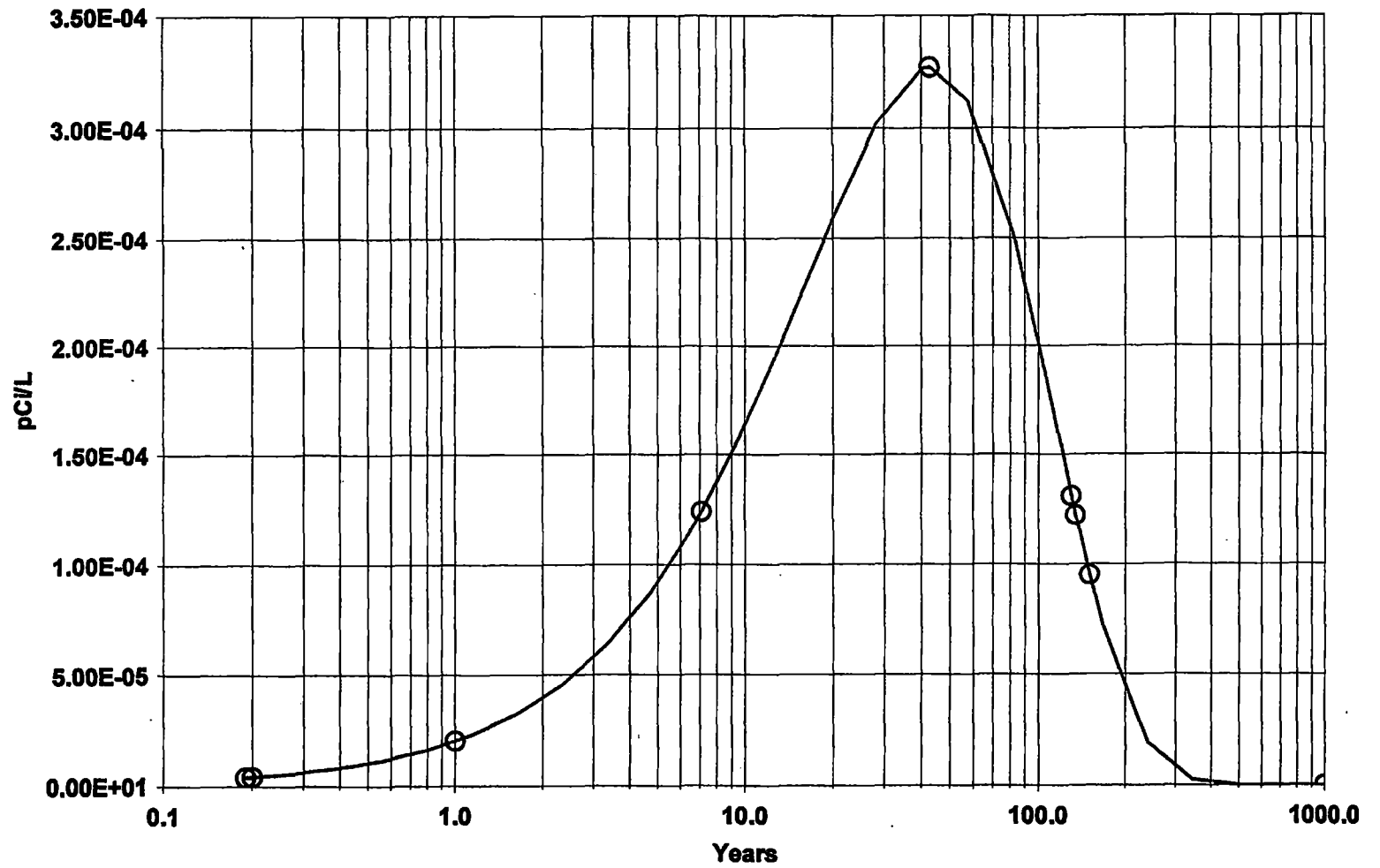
**CONCENTRATION: Co-60, Well Water**



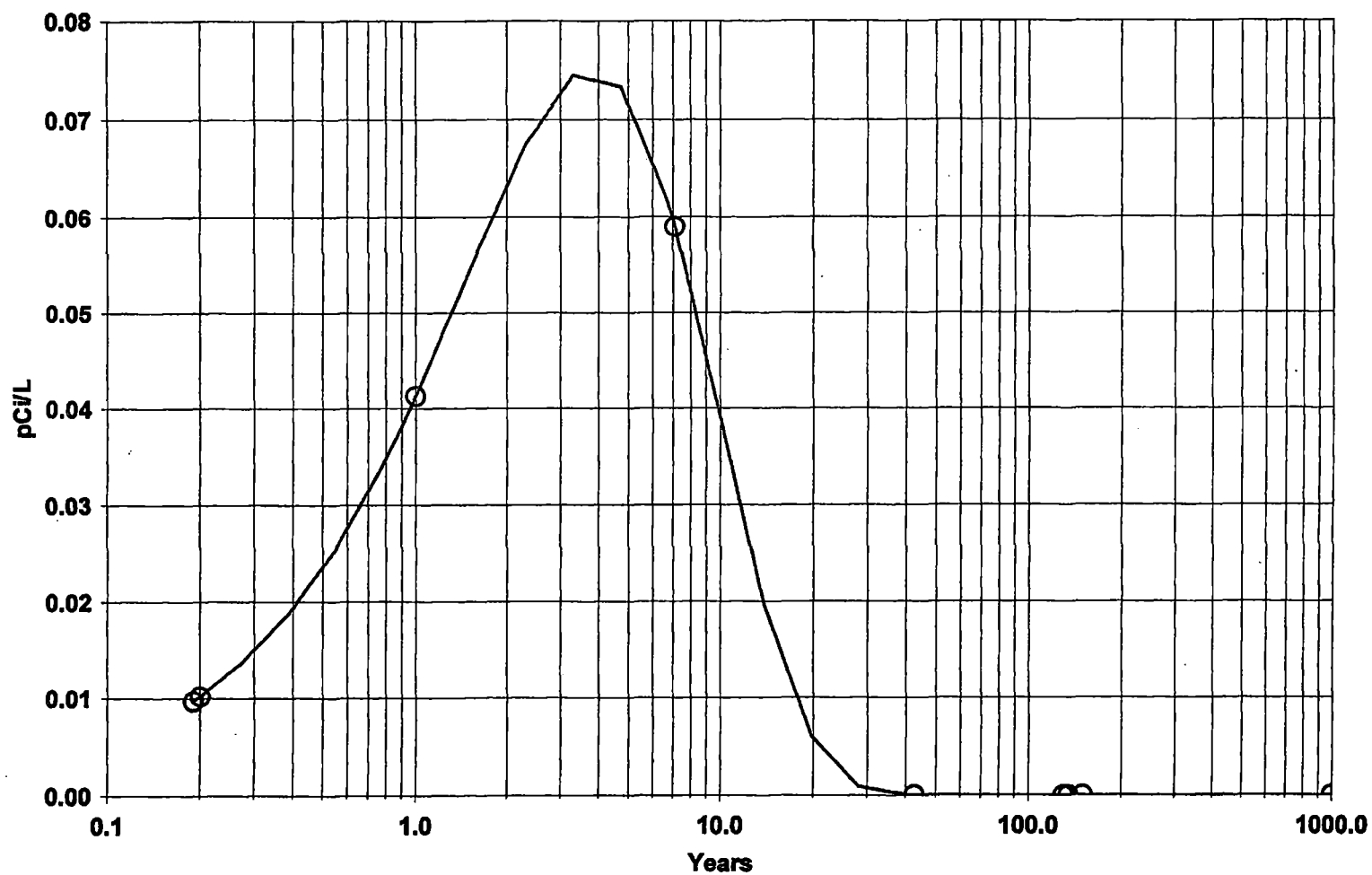
**CONCENTRATION: Cs-134, Well Water**



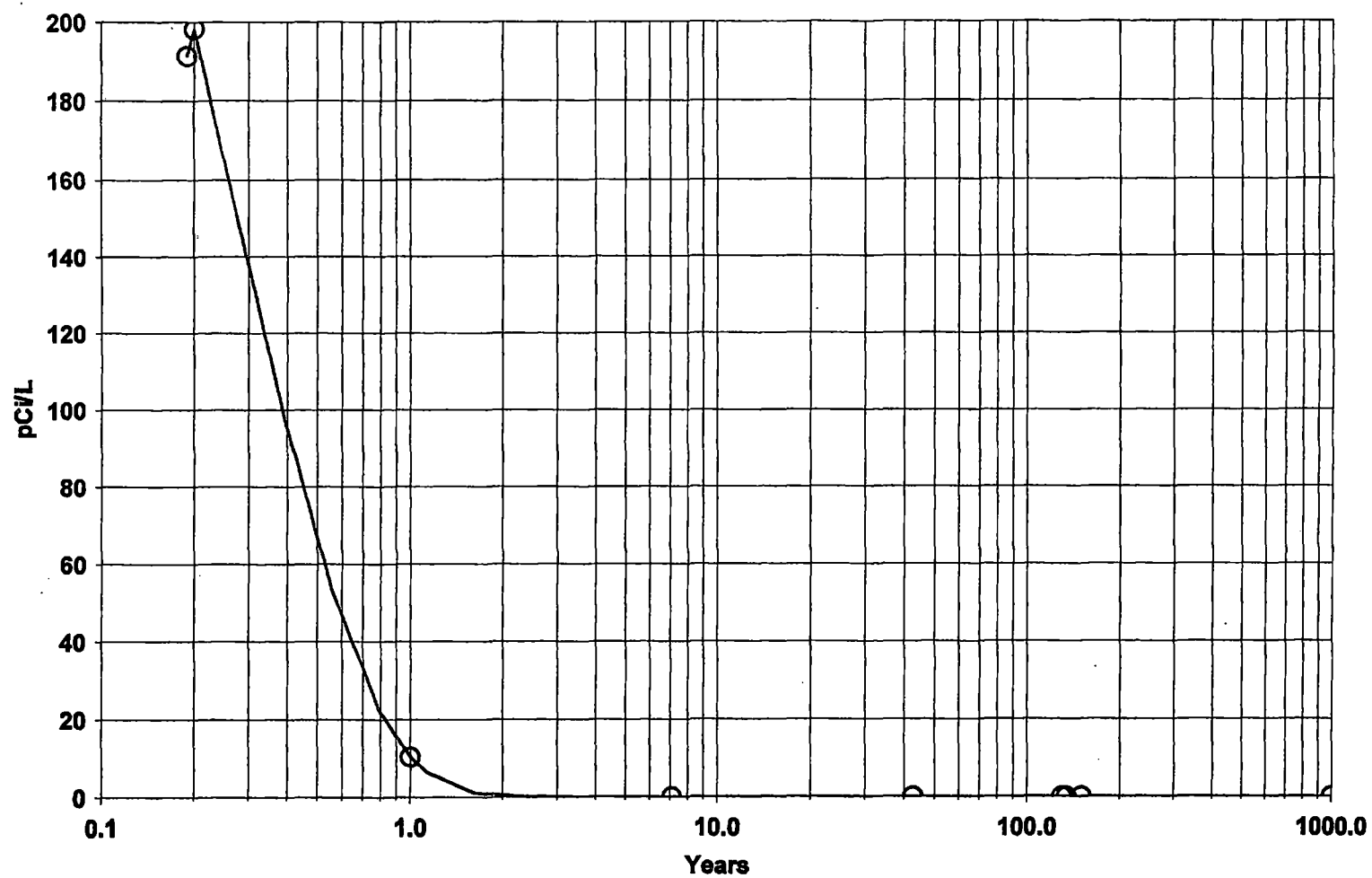
**CONCENTRATION: Cs-137, Well Water**



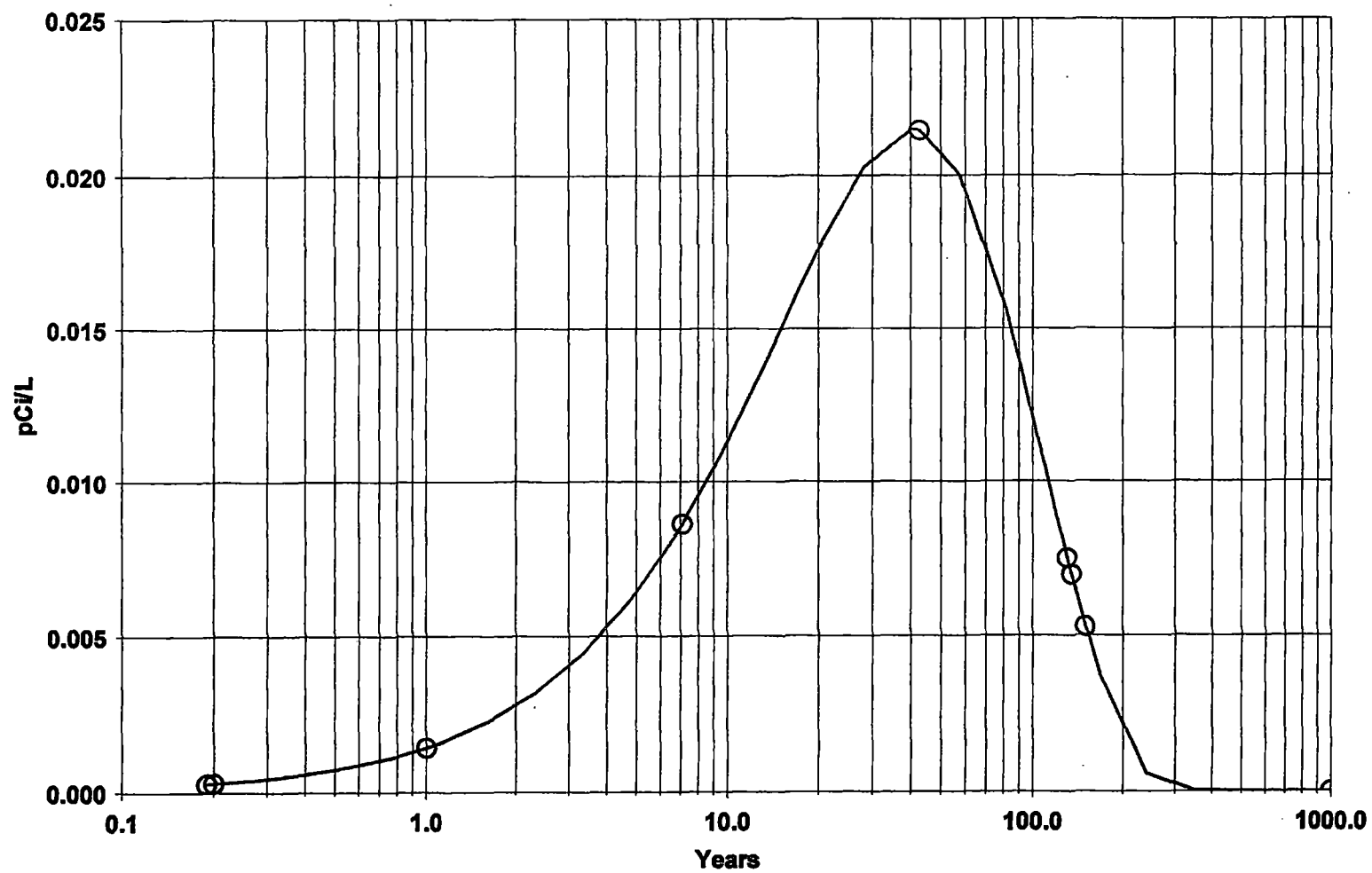
**CONCENTRATION: Fe-55, Well Water**



**CONCENTRATION: H-3, Well Water**



**CONCENTRATION: Sr-90, Well Water**



**Attachment 6-12  
Buried Piping Microshield Output**

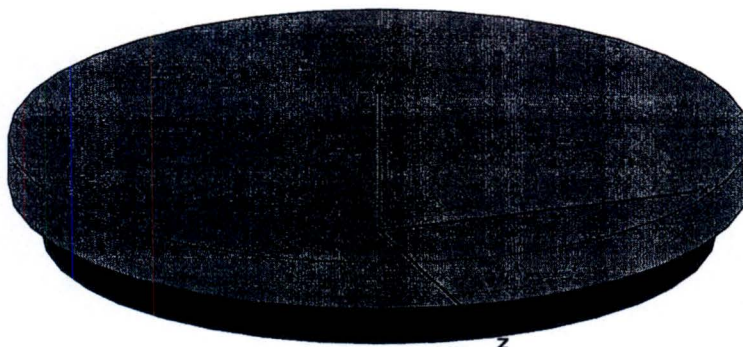
MicroShield v5.01 (5.01-00010)  
Maine Yankee Atomic Power

Page : 1  
DOS File: Case1  
Run Date: September 25, 2002  
Run Time: 10:40:31 AM  
Duration: 00:00:00

File Ref: 017-01  
Date: 9-25-02  
By: RYD  
Checked:

( Illustration of  
Geometry )

Case Title: Cs-137  
Description: Case 1  
Geometry: 8 - Cylinder Volume - End Shields



Source Dimensions

Height	100.0 cm	3 ft 3.4 in
Radius	671.0 cm	22 ft 0.2 in

Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	0 cm	300 cm	0 cm
	0.0 in	9 ft 10.1 in	0.0 in

Shields

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	141.447 m <sup>3</sup>	SiO2	1.6
Shield 1	1.0 m	SiO2	1.6
Air Gap		Air	0.00122

Source Input

Grouping Method : Actual Photon Energies

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>μCi/cm<sup>3</sup></u>	<u>Bq/cm<sup>3</sup></u>
Ba-137m	2.2632e-004	8.3738e+006	1.6000e-006	5.9201e-002
Cs-137	2.2632e-004	8.3738e+006	1.6000e-006	5.9201e-002

Buildup

The material reference is : Shield 1

Integration Parameters

Radial	20
Circumferential	10
Y Direction (axial)	10

Results

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.0318	1.734e+05	1.881e-64	5.623e-29	1.567e-66	4.684e-31



Page : 2  
DOS File: Case1  
Run Date: September 25, 2002  
Run Time: 10:40:31 AM  
Duration: 00:00:00

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.0322	3.199e+05	1.593e-62	1.082e-28	1.282e-64	8.710e-31
0.0364	1.164e+05	9.643e-49	6.663e-29	5.479e-51	3.786e-31
0.6616	7.535e+06	4.403e-08	2.569e-06	8.535e-11	4.980e-09
TOTALS:	8.144e+06	4.403e-08	2.569e-06	8.535e-11	4.980e-09

MicroShield v5.01 (5.01-00010)

09/25/02

MicroShield v5.01 (5.01-00010)  
Maine Yankee Atomic Power  
Conversion of calculated exposure in air to dose  
FILE: Case1  
Case Title: Cs-134  
This case was run on Wednesday, September 25, 2002 at 10:33:42 AM  
Dose Point # 1 - (0,3,0) m

<u>Results (Summed over energies)</u>	<u>Units</u>	<u>Without Buildup</u>	<u>With Buildup</u>
Photon Fluence Rate (flux)	Photons/cm <sup>2</sup> /sec	4.865e-007	1.673e-005
Photon Energy Fluence Rate	MeV/cm <sup>2</sup> /sec	4.899e-007	1.472e-005
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	8.871e-010	2.727e-008
Absorbed Dose Rate in Air	mGy/hr	7.744e-012	2.380e-010
"	mrads/hr	7.744e-010	2.380e-008
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	8.905e-012	2.759e-010
o Opposed	"	7.502e-012	2.291e-010
o Rotational	"	7.502e-012	2.291e-010
o Isotropic	"	6.675e-012	2.033e-010
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	9.488e-012	2.941e-010
o Opposed	"	9.101e-012	2.813e-010
o Rotational	"	9.101e-012	2.813e-010
o Isotropic	"	7.097e-012	2.167e-010
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	7.976e-012	2.463e-010
o Posterior/Anterior	"	7.253e-012	2.221e-010
o Lateral	"	5.651e-012	1.705e-010
o Rotational	"	6.515e-012	1.991e-010
o Isotropic	"	5.695e-012	1.727e-010

09/25/02

MicroShield v5.01 (5.01-00010)

MicroShield v5.01 (5.01-00010)  
Maine Yankee Atomic Power  
Conversion of calculated exposure in air to dose

FILE: Case1

Case Title: Cs-137

This case was run on Wednesday, September 25, 2002 at 10:40:31 AM  
Dose Point # 1 - (0,3,0) m

<u>Results (Summed over energies)</u>	<u>Units</u>	<u>Without Buildup</u>	<u>With Buildup</u>
Photon Fluence Rate (flux)	Photons/cm <sup>2</sup> /sec	6.654e-008	3.882e-006
Photon Energy Fluence Rate	MeV/cm <sup>2</sup> /sec	4.403e-008	2.569e-006
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	8.535e-011	4.980e-009
Absorbed Dose Rate in Air	mGy/hr	7.451e-013	4.347e-011
"	mrads/hr	7.451e-011	4.347e-009
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	8.822e-013	5.147e-011
o Opposed	"	7.063e-013	4.121e-011
o Rotational	"	7.063e-013	4.121e-011
o Isotropic	"	6.246e-013	3.644e-011
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	9.376e-013	5.470e-011
o Opposed	"	8.906e-013	5.196e-011
o Rotational	"	8.906e-013	5.196e-011
o Isotropic	"	6.677e-013	3.896e-011
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	7.801e-013	4.551e-011
o Posterior/Anterior	"	6.885e-013	4.017e-011
o Lateral	"	5.106e-013	2.979e-011
o Rotational	"	6.153e-013	3.590e-011
o Isotropic	"	5.238e-013	3.056e-011

09/25/02

MicroShield v5.01 (5.01-00010)

MicroShield v5.01 (5.01-00010)  
Maine Yankee Atomic Power  
Conversion of calculated exposure in air to dose

FILE: Casel

Case Title: Co-60

This case was run on Wednesday, September 25, 2002 at 10:37:19 AM  
Dose Point # 1 - (0,3,0) m

<u>Results (Summed over energies)</u>	<u>Units</u>	<u>Without Buildup</u>	<u>With Buildup</u>
Photon Fluence Rate (flux)	Photons/cm <sup>2</sup> /sec	7.087e-006	1.378e-004
Photon Energy Fluence Rate	MeV/cm <sup>2</sup> /sec	9.071e-006	1.753e-004
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.588e-008	3.074e-007
Absorbed Dose Rate in Air	mGy/hr	1.386e-010	2.683e-009
"	mrads/hr	1.386e-008	2.683e-007
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.573e-010	3.046e-009
o Opposed	"	1.356e-010	2.624e-009
o Rotational	"	1.356e-010	2.624e-009
o Isotropic	"	1.212e-010	2.345e-009
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.674e-010	3.242e-009
o Opposed	"	1.613e-010	3.122e-009
o Rotational	"	1.613e-010	3.122e-009
o Isotropic	"	1.284e-010	2.484e-009
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.417e-010	2.743e-009
o Posterior/Anterior	"	1.306e-010	2.527e-009
o Lateral	"	1.040e-010	2.011e-009
o Rotational	"	1.176e-010	2.276e-009
o Isotropic	"	1.042e-010	2.015e-009

09/25/02

MicroShield v5.01 (5.01-00010)

MicroShield v5.01 (5.01-00010)  
Maine Yankee Atomic Power  
Conversion of calculated exposure in air to dose  
FILE: Case1  
Case Title: Co-57  
This case was run on Wednesday, September 25, 2002 at 10:42:32 AM  
Dose Point # 1 - (0,3,0) m

<u>Results (Summed over energies)</u>	<u>Units</u>	<u>Without Buildup</u>	<u>With Buildup</u>
Photon Fluence Rate (flux)	Photons/cm <sup>2</sup> /sec	1.628e-010	9.016e-009
Photon Energy Fluence Rate	MeV/cm <sup>2</sup> /sec	1.117e-010	6.114e-009
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.157e-013	1.181e-011
Absorbed Dose Rate in Air	mGy/hr	1.883e-015	1.031e-013
"	mrads/hr	1.883e-013	1.031e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.223e-015	1.218e-013
o Opposed	"	1.788e-015	9.789e-014
o Rotational	"	1.788e-015	9.789e-014
o Isotropic	"	1.581e-015	8.655e-014
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.366e-015	1.296e-013
o Opposed	"	2.250e-015	1.232e-013
o Rotational	"	2.250e-015	1.232e-013
o Isotropic	"	1.691e-015	9.256e-014
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.968e-015	1.078e-013
o Posterior/Anterior	"	1.742e-015	9.541e-014
o Lateral	"	1.298e-015	7.102e-014
o Rotational	"	1.557e-015	8.527e-014
o Isotropic	"	1.329e-015	7.272e-014

**MYAPC License Termination Plan**  
**Revision 4**  
**February 28, 2005**

**Attachment 6-13**  
**DCGL/Total Dose Spreadsheets**

| ☐  
| ☐

**Table 6-11**  
**Contaminated Material DCGL**

Refer to Section 6 for Table 6-11 (Table 6-11a for Containment, Table 6-11b for Non-Containment)

**(Containment)**  
**Contaminated Concrete**

Attachment 6-13  
Page 3 of 24

**CONTAMINATED CONCRETE**

**Key Parameters:**

Porosity	0.30		Concrete Density	2.20	g/cm <sup>3</sup>
Bulk Density	1.50	g/cm <sup>3</sup>	Annual Total Well Water Vol	738.0	m <sup>3</sup>
Yearly Drinking Water	478.0	L/yr	Irrigation Rate	0.274	L/m <sup>2</sup> -d
Wall Surface Area	1131.6	m <sup>2</sup>	Surface Soil Depth	0.15	m
Fill Volume	2460.0	m <sup>3</sup>	Gross Beta DCGL	1.80E+04	dpm/100 cm <sup>2</sup>
Surface Area/Open Volume	0.46	m <sup>2</sup> /m <sup>3</sup>	Gross Beta Nuclide Fraction	0.6160	
Concrete Volume	1.13	m <sup>3</sup>	Total Inventory	2.92E+04	dpm/100 cm <sup>2</sup>

DOSE CALCULATION FACTORS				SOURCE TERM			Kd		WATER, FILL, CONCRETE CONCENTRATION				CONTAMINATED CONCRETE ANNUAL DOSE				
Nuclide	NUREG-1727 mrem/y per pCi/g	FGR 11 mrem/pCi	Microshield mrem/y per pCi/g	Nuclide Fraction	Inventory dpm/100 cm <sup>2</sup>	Inventory pCi	Kd Fill cm <sup>3</sup> /gm	Kd Concrete cm <sup>3</sup> /gm	Adsorption Factor	Water pCi/L	Fill pCi/g	Concrete pCi/g	Nuclide	Drinking Water Dose mrem/y	Irrigation Dose mrem/y	Direct Dose mrem/y	Total Dose mrem/y
Sr-90	1.47E+01	1.42E-04	0.00E+00	2.80E-03	8.19E+01	4.17E+06	6.02E+01	1.00E+00	3.02E+02	1.87E-02	1.13E-03	1.87E-05	Sr-90	1.27E-03	1.22E-04	0.00E+00	1.39E-03
Cs-134	4.39E+00	7.33E-05	6.09E-05	4.55E-03	1.33E+02	6.77E+06	7.91E+01	3.00E+00	3.96E+02	2.31E-02	1.83E-03	6.94E-05	Cs-134	8.11E-04	4.52E-05	1.12E-07	8.56E-04
Cs-137	2.27E+00	5.00E-05	1.20E-05	5.50E-01	1.61E+04	8.20E+08	7.91E+01	3.00E+00	3.96E+02	2.80E+00	2.22E-01	8.40E-03	Cs-137	6.69E-02	2.83E-03	2.66E-06	6.98E-02
Co-60	6.58E+00	2.69E-05	6.30E-04	5.84E-02	1.71E+03	8.70E+07	1.28E+02	1.00E+02	6.40E+02	1.84E-01	2.35E-02	1.84E-02	Co-60	2.37E-03	5.39E-04	1.48E-05	2.92E-03
Co-57	1.67E-01	1.18E-06	2.80E-08	3.06E-04	8.95E+00	4.56E+05	1.28E+02	1.00E+02	6.40E+02	9.66E-04	1.23E-04	9.66E-05	Co-57	5.45E-07	7.17E-08	3.46E-12	6.17E-07
Fe-55	2.50E-03	6.07E-07	0.00E+00	4.81E-03	1.41E+02	7.17E+06	2.50E+01	1.00E+02	1.26E+02	7.69E-02	1.92E-03	7.69E-03	Fe-55	2.23E-05	8.55E-08	0.00E+00	2.24E-05
H-3	2.27E-01	6.40E-08	0.00E+00	2.36E-02	6.88E+02	3.51E+07	0.00E+00	0.00E+00	1.00E+00	4.75E+01	0.00E+00	0.00E+00	H-3	1.45E-03	4.79E-03	0.00E+00	6.25E-03
Ni-63	1.19E-02	5.77E-07	0.00E+00	3.55E-01	1.04E+04	5.29E+08	1.28E+02	1.00E+02	6.40E+02	1.12E+00	1.43E-01	1.12E-01	Ni-63	3.09E-04	5.92E-06	0.00E+00	3.15E-04
													SUM	7.32E-02	8.33E-03	1.76E-05	8.15E-02



(Containment)  
Surface Soil

**SURFACE SOIL**

**Key Parameters:**

Soil Depth	0.15	m
Surface Soil (Cs-137) Concentration	2.39	pCi/g
Surface Soil Total Concentration	2.69	pCi/g

DOSE CALCULATION FACTORS		SOURCE TERM		SURFACE SOIL ANNUAL DOSE
Nuclide	NUREG-1727 mrem/y per pCi/g	Nuclide Fraction	Soil pCi/g	Total Dose mrem/y
Cs-137	2.27E+00	8.90E-01	2.39E+00	5.43E+00
Co-60	6.58E+00	9.00E-03	2.42E-02	1.59E-01
H-3	2.27E-01	5.30E-02	1.43E-01	3.24E-02
Ni-63	1.19E-02	4.80E-02	1.29E-01	1.54E-03
SUM				5.63E+00

8/14/03

**(Containment)  
Activated Concrete**

Attachment 6-13  
Page 5 of 24

**ACTIVATED CONCRETE (50 yr Liner Breach and Diffusion)**

**Key Parameters:**

Porosity	0.30		Concrete Density	2.20	g/cm <sup>3</sup>
Bulk Density	1.50	g/cm <sup>3</sup>	Annual Total Well Water Vol	738.0	m <sup>3</sup>
Yearly Drinking Water	478.0	L/yr	Irrigation Rate	0.274	L/m <sup>2</sup> -d
Wall Surface Area	1131.6	m <sup>2</sup>	Surface Soil Depth	0.15	m
Fill Volume	2460.0	m <sup>3</sup>	Activated Concrete Total Inventory	4.88E+08	pCi
Surface Area/Open Volume	0.46	m <sup>2</sup> /m <sup>3</sup>			
Concrete Volume	1.13	m <sup>3</sup>			

DOSE CALCULATION FACTORS				SOURCE TERM		Kd		WATER, FILL, CONCRETE CONCENTRATION				ACTIVATED CONCRETE ANNUAL DOSE				
Nuclide	NUREG-1727 mrem/y per pCi/g	FGR 11 mrem/pCi	Microshield mrem/y per pCi/g	Nuclide Fraction	Inventory pCi	Kd Fill cm <sup>3</sup> /gm	Kd Concrete cm <sup>3</sup> /gm	Adsorption Factor	Water pCi/L	Fill pCi/g	Concrete pCi/g	Nuclide	Drinking Water Dose mrem/y	Irrigation Dose mrem/y	Direct Dose mrem/y	Total Dose mrem/y
Cs-134	4.39E+00	7.33E-05	6.09E-05	5.72E-03	2.79E+06	7.91E+01	3.00E+00	3.96E+02	9.54E-03	7.55E-04	2.86E-05	Cs-134	3.34E-04	1.86E-05	4.60E-08	3.53E-04
Co-60	6.58E+00	2.69E-05	6.30E-04	2.73E-02	1.33E+07	1.28E+02	1.00E+02	6.40E+02	2.82E-02	3.60E-03	2.82E-03	Co-60	3.63E-04	8.25E-05	2.27E-06	4.47E-04
C-14	2.08E+00	2.09E-06	0.00E+00	1.48E-01	7.22E+07	5.00E+00	1.00E+02	2.63E+01	3.72E+00	1.86E-02	3.72E-01	C-14	3.71E-03	3.44E-03	0.00E+00	7.15E-03
Eu-154	3.13E+00	9.55E-06	3.10E-04	6.10E-03	2.98E+06	4.00E+02	5.00E+03	2.02E+03	2.00E-03	8.00E-04	9.99E-03	Eu-154	9.12E-06	2.78E-06	2.48E-07	1.21E-05
Fe-55	2.50E-03	6.07E-07	0.00E+00	8.44E-02	4.12E+07	2.50E+01	1.00E+02	1.26E+02	4.42E-01	1.10E-02	4.42E-02	Fe-55	1.28E-04	4.91E-07	0.00E+00	1.29E-04
H-3	2.27E-01	6.40E-08	0.00E+00	4.41E-01	2.15E+08	0.00E+00	0.00E+00	1.00E+00	2.91E+02	0.00E+00	0.00E+00	H-3	8.92E-03	2.94E-02	0.00E+00	3.83E-02
Eu-152	2.87E+00	6.48E-06	2.09E-04	7.56E-02	3.69E+07	4.00E+02	5.00E+03	2.02E+03	2.48E-02	9.91E-03	1.24E-01	Eu-152	7.67E-05	3.16E-05	2.07E-06	1.10E-04
Ni-63	1.19E-02	5.77E-07	0.00E+00	2.11E-01	1.03E+08	1.28E+02	1.00E+02	6.40E+02	2.18E-01	2.78E-02	2.18E-02	Ni-63	6.01E-05	1.15E-06	0.00E+00	6.13E-05
				9.99E-01	4.88E+08							SUM	1.36E-02	3.30E-02	4.63E-06	4.66E-02

**(Containment)  
Activated Rebar**

Attachment 6-13  
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**Activated Rebar**

**Key Parameters:**

Porosity	0.30		Concrete Density	2.20	g/cm <sup>3</sup>
Bulk Density	1.50	g/cm <sup>3</sup>	Annual Total Well Water Vol	738.0	m <sup>3</sup>
Yearly Drinking Water	478.0	L/yr	Irrigation Rate	0.274	L/m <sup>2</sup> -d
Wall Surface Area	1131.6	m <sup>2</sup>	Surface Soil Depth	0.15	m
Fill Volume	2460.0	m <sup>3</sup>	Activated Concrete Total Inventory	9.01E+08	pCi (1.9*Activated Concrete Inventory)
Surface Area/Open Volume	0.46	m <sup>2</sup> /m <sup>3</sup>			
Concrete Volume	1.13	m <sup>3</sup>			

DOSE CALCULATION FACTORS				SOURCE TERM		Kd		WATER, FILL, CONCRETE CONCENTRATION				ACTIVATED REBAR ANNUAL DOSE				
Nuclide	NUREG-1727	FGR 11	Microshield	Nuclide	Inventory	Kd	Kd	Adsorption	Water	Fill	Concrete	Nuclide	Drinking	Irrigation	Direct	Total
	mrem/y per pCi/g	mrem/pCi	mrem/y per pCi/g										Water Dose	Dose	Dose	Dose
				Fraction	pCi	cm <sup>3</sup> /gm	cm <sup>3</sup> /gm	Factor	pCi/L	pCi/g	pCi/g		mrem/y	mrem/y	mrem/y	mrem/y
Cs-134	4.39E+00	7.33E-05	6.09E-05	0.00E+00	0.00E+00	7.91E+01	3.00E+00	3.96E+02	0.00E+00	0.00E+00	0.00E+00	Cs-134	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Co-60	6.58E+00	2.69E-05	6.30E-04	3.00E-02	2.70E+07	1.28E+02	1.00E+02	6.40E+02	5.72E-02	7.31E-03	5.72E-03	Co-60	7.36E-04	1.67E-04	4.61E-06	9.08E-04
C-14	2.08E+00	2.09E-06	0.00E+00	0.00E+00	0.00E+00	5.00E+00	1.00E+02	2.63E+01	0.00E+00	0.00E+00	0.00E+00	C-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Eu-154	3.13E+00	9.55E-06	3.10E-04	0.00E+00	0.00E+00	4.00E+02	5.00E+03	2.02E+03	0.00E+00	0.00E+00	0.00E+00	Eu-154	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Fe-55	2.50E-03	6.07E-07	0.00E+00	8.18E-04	7.37E+05	2.50E+01	1.00E+02	1.26E+02	7.90E-03	1.98E-04	7.90E-04	Fe-55	2.29E-06	8.78E-09	0.00E+00	2.30E-06
H-3	2.27E-01	6.40E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	0.00E+00	0.00E+00	0.00E+00	H-3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Eu-152	2.87E+00	6.48E-06	2.09E-04	0.00E+00	0.00E+00	4.00E+02	5.00E+03	2.02E+03	0.00E+00	0.00E+00	0.00E+00	Eu-152	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ni-63	1.19E-02	5.77E-07	0.00E+00	9.69E-01	8.73E+08	1.28E+02	1.00E+02	6.40E+02	1.85E+00	2.36E-01	1.85E-01	Ni-63	5.10E-04	9.78E-06	0.00E+00	5.19E-04
SUM													1.25E-03	1.77E-04	4.61E-06	1.43E-03

**(Containment)  
Deep Soil**

**DEEP SOIL**

**Key Parameters:**

Porosity	0.3		Surface Soil Depth	0.15	m
Bulk Density	1.6	g/cm <sup>3</sup>	Deep Soil (Cs-137) Concentration	(Limited to 2.39)	4.31 pCi/g
Yearly Drinking Water	478	L/y	Deep Soil Total Concentration		4.83 pCi/g
Irrigation Rate	0.274	L/m <sup>2</sup> -d			

Using ResRad results for pCi/L per pCi/g conversion Table 1 of EC-018-01 half sand half gravel(.44) 6/18/02

DOSE CALCULATION FACTORS				SOURCE TERM				DEEP SOIL ANNUAL DOSE			
Nuclide	NUREG-1727 mrem/y per pCi/g	FGR 11 mrem/pCi	Microshield mrem/y per pCi/g	Nuclide Fraction	Deep Soil Inventory pCi/g	Derived Water Conversion Units pCi/L per pCi/g	Water Inventory pCi/L	Drinking Water Dose mrem/y	Irrigation Dose mrem/y	Direct Dose mrem/y	Total Dose mrem/y
Cs-137	2.27E+00	5.00E-05	4.00E-01	8.90E-01	4.30E+00	9.02E-03	3.87E-02	9.26E-04	3.66E-05	1.72E+00	1.72E+00
Co-60	6.58E+00	2.69E-05	2.40E+00	9.00E-03	4.34E-02	2.24E-02	9.74E-04	1.25E-05	2.67E-06	1.04E-01	1.04E-01
H-3	2.27E-01	6.40E-08	0.00E+00	5.30E-02	2.56E-01	6.69E+03	1.71E+03	5.23E-02	1.62E-01	0.00E+00	2.14E-01
Ni-63	1.19E-02	5.77E-07	0.00E+00	4.80E-02	2.32E-01	6.01E-01	1.39E-01	3.84E-05	6.90E-07	0.00E+00	3.91E-05
								5.33E-02	1.62E-01	1.82E+00	2.04E+00

1/11/2005

**(Containment)  
Ground Water**

**Attachment 6-13  
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**GROUND WATER**

**Key Parameters:**

Annual Water Intake      478    L/y

Dose Calculation Factors		Source Term		Ground Water Annual Dose	
Nuclide	FGR 11 mrem/pCi	Nuclide Fraction	Inventory pCi/L	Drinking Water Dose mrem/y	
H-3	6.40E-08	1.00E+00	6,812	2.08E-01	
SUM				2.08E-01	

8/30/02

**(Containment)  
Surface Water**

**Attachment 6-13  
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**SURFACE WATER**

**Key Parameters:**

Annual Water Intake	478	L/y
Annual Fish Consumption	20.6	Kg/y

Dose Calculation factors			Source Term		Surface Water Annual Dose		
Nuclide	FGR 11 mrem/pCi	Bioaccumulation Factor for Fish pCi/Kg per pCi/L	Nuclide Fraction	Water Inventory pCi/L	Drinking Water Dose mrem/y	Fish Ingestion Dose mrem/y	Total Dose mrem/y
H-3	6.40E-08	1.00E+00	1.00E+00	960	2.94E-02	1.27E-03	3.06E-02
				SUM	2.94E-02	1.27E-03	3.06E-02

**(Containment)  
Buried Piping**

Attachment 6-13  
Page 10 of 24

**BURIED PIPING**

**Key Parameters:**

Porosity	0.3		Buried Pipe Conversion Factor	2.59E-04	pCi/g per dpm/100 cm <sup>2</sup>
Bulk Density	1.6	g/cm <sup>3</sup>	Gross Beta DCGL	9.80E+03	dpm/100 cm <sup>2</sup>
Yearly Drinking Water	478	L/y	Gross Beta Nuclide Fraction	0.616	
Irrigation Rate	0.274	L/m <sup>2</sup> -d	Total Inventory	1.59E+04	dpm/100 cm <sup>2</sup>
Surface Soil Depth	0.15	m			

Dose Calculation Factors				Source Term				Buried Piping Annual Dose			
Nuclide	FGR 11 mrem/pCi	NUREG-1727 mrem/y per pCi/g	Microshield mrem/y per pCi/g	Nuclide Fraction	Water Inventory pCi/L per pCi/g	Pipe Surface Inventory dpm/100cm <sup>2</sup>	Soil Inventory pCi/g	Drinking Water Dose mrem/y	Irrigation Dose mrem/y	Direct Dose mrem/y	Total Dose mrem/y
Sr-90	1.42E-04	1.47E+01	0.00E+00	2.80E-03	2.15E-02	4.46E+01	1.15E-02	1.68E-05	1.52E-06	0.00E+00	1.83E-05
Cs-134	7.33E-05	4.39E+00	2.21E-05	4.55E-03	2.25E-05	7.23E+01	1.87E-02	1.48E-08	7.71E-10	4.14E-07	4.30E-07
Cs-137	5.00E-05	2.27E+00	3.97E-06	5.50E-01	3.27E-04	8.75E+03	2.27E+00	1.77E-05	7.01E-07	9.01E-06	2.74E-05
Co-60	2.69E-05	6.58E+00	2.53E-04	5.84E-02	8.14E-04	9.29E+02	2.41E-01	2.52E-06	5.37E-07	6.09E-05	6.40E-05
Co-57	1.18E-06	1.67E-01	9.44E-09	3.06E-04	1.15E-04	4.88E+00	1.26E-03	8.18E-11	1.01E-11	1.19E-11	1.04E-10
Fe-55	6.07E-07	2.50E-03	0.00E+00	4.81E-03	4.30E-05	7.66E+01	1.98E-02	2.47E-10	8.89E-13	0.00E+00	2.48E-10
H-3	6.40E-08	2.27E-01	0.00E+00	2.36E-02	1.98E+02	3.75E+02	9.70E-02	5.88E-04	1.82E-03	0.00E+00	2.41E-03
Ni-63	5.77E-07	1.19E-02	0.00E+00	3.55E-01	2.09E-02	5.65E+03	1.46E+00	8.42E-06	1.51E-07	0.00E+00	8.57E-06
							<b>SUM</b>	6.33E-04	1.82E-03	7.03E-05	2.52E-03

**(Containment)**  
**BOP Embedded Piping**

Attachment 6-13  
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**BOP EMBEDDED PIPE**

**Key Parameters:**

Porosity	0.30		Concrete Density	2.20	g/cm <sup>3</sup>
Bulk Density	1.50	g/cm <sup>3</sup>	Surface Soil Depth	0.15	m
Yearly Drinking Water	478.0	l/yr	Irrigation Rate	0.274	L/m <sup>2</sup> -d
Wall Surface Area	1131.6	m <sup>2</sup>	Annual Total Well Water Vol	738	m <sup>3</sup>
Fill Volume	2460.0	m <sup>3</sup>	Embedded Pipe Conversion Factor	5754.5	pCi per dpm/100 cm <sup>2</sup>
Surface Area/Open Volume	0.46	m <sup>2</sup> /m <sup>3</sup>	Gross Beta DCGL	1.00E+05	dpm/100 cm <sup>2</sup>
Concrete Volume	1.13	m <sup>3</sup>	Gross Beta Nuclide Fraction	0.616	
			Total Inventory	1.62E+05	dpm/100 cm <sup>2</sup>

DOSE CALCULATION FACTORS				SOURCE TERM			Kd		WATER, FILL, CONCRETE CONCENTRATION				EMBEDDED PIPE ANNUAL DOSE				
Nuclide	NUREG-1727 mrem/y per pCi/g	FGR 11 mrem/pCi	Microshield mrem/y per pCi/g	Fraction	Inventory dpm/100 cm <sup>2</sup>	Inventory pCi	Kd Fill cm <sup>3</sup> /gm	Kd Concrete cm <sup>3</sup> /gm	Adsorption Factor	Water pCi/L	Fill pCi/g	Concrete pCi/g	Nuclide	Drinking Water Dose mrem/y	Irrigation Dose mrem/y	Direct Dose mrem/y	Total Dose mrem/y
Sr-90	1.47E+01	1.42E-04	0.00E+00	2.80E-03	4.55E+02	2.62E+06	6.02E+01	1.00E+00	3.02E+02	1.18E-02	7.07E-04	1.18E-05	Sr-90	7.98E-04	7.68E-05	0.00E+00	8.75E-04
Cs-134	4.39E+00	7.33E-05	6.09E-05	4.55E-03	7.38E+02	4.25E+06	7.91E+01	3.00E+00	3.96E+02	1.45E-02	1.15E-03	4.36E-05	Cs-134	5.09E-04	2.83E-05	6.99E-08	5.37E-04
Cs-137	2.27E+00	5.00E-05	1.20E-05	5.50E-01	8.93E+04	5.14E+08	7.91E+01	3.00E+00	3.96E+02	1.76E+00	1.39E-01	5.27E-03	Cs-137	4.20E-02	1.77E-03	1.67E-06	4.38E-02
Co-60	6.58E+00	2.69E-05	6.30E-04	5.84E-02	9.48E+03	5.46E+07	1.28E+02	1.00E+02	6.40E+02	1.16E-01	1.48E-02	1.16E-02	Co-60	1.49E-03	3.38E-04	9.30E-06	1.83E-03
Co-57	1.67E-01	1.18E-06	2.80E-08	3.06E-04	4.97E+01	2.86E+05	1.28E+02	1.00E+02	6.40E+02	6.06E-04	7.74E-05	6.06E-05	Co-57	3.42E-07	4.50E-08	2.17E-12	3.87E-07
Fe-55	2.50E-03	6.07E-07	0.00E+00	4.81E-03	7.82E+02	4.50E+06	2.50E+01	1.00E+02	1.26E+02	4.82E-02	1.21E-03	4.82E-03	Fe-55	1.40E-05	5.36E-08	0.00E+00	1.40E-05
H-3	2.27E-01	6.40E-08	0.00E+00	2.36E-02	3.82E+03	2.20E+07	0.00E+00	0.00E+00	1.00E+00	2.98E+01	0.00E+00	0.00E+00	H-3	9.12E-04	3.01E-03	0.00E+00	3.92E-03
Ni-63	1.19E-02	5.77E-07	0.00E+00	3.55E-01	5.77E+04	3.32E+08	1.28E+02	1.00E+02	6.40E+02	7.02E-01	8.97E-02	7.02E-02	Ni-63	1.94E-04	3.72E-06	0.00E+00	1.97E-04
SUM														4.59E-02	5.23E-03	1.10E-05	5.11E-02



**(Containment)**  
**Spray Building Embedded Pump Piping**

Attachment 6-13  
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**EMBEDDED SPRAY PUMP PIPING**

**Key Parameters:**

Porosity	0.30		Concrete Density	2.20	g/cm <sup>3</sup>
Bulk Density	1.50	g/cm <sup>3</sup>	Surface Soil Depth	0.15	m
Yearly Drinking Water	478.0	l/yr	Irrigation Rate	0.274	L/m <sup>2</sup> -d
Wall Surface Area	1131.6	m <sup>2</sup>	Annual Total Well Water Vol	738	m <sup>3</sup>
Fill Volume	2460.0	m <sup>3</sup>	Embedded Pipe Conversion Factor	1191.7	pCi per dpm/100 cm <sup>2</sup>
Surface Area/Open Volume	0.46	m <sup>2</sup> /m <sup>3</sup>	Gross Beta DCGL	8.00E+05	dpm/100 cm <sup>2</sup>
Concrete Volume	1.13	m <sup>3</sup>	Gross Beta Nuclide Fraction	0.616	
			Total Inventory	1.30E+06	dpm/100 cm <sup>2</sup>

DOSE CALCULATION FACTORS				SOURCE TERM			Kd		WATER, FILL, CONCRETE CONCENTRATION				EMBEDDED PIPE ANNUAL DOSE				
Nuclide	NUREG-1727	FGR 11	Microshield	Fraction	Inventory	Inventory	Kd	Kd	Adsorption	Water	Fill	Concrete	Nuclide	Drinking	Irrigation	Direct	Total
	mrem/y per pCi/g	mrem/pCi	mrem/y per pCi/g		dpm/100 cm <sup>2</sup>	pCi								Water Dose mrem/y	Dose mrem/y	Dose mrem/y	Dose mrem/y
Sr-90	1.47E+01	1.42E-04	0.00E+00	2.80E-03	3.64E+03	4.34E+06	6.02E+01	1.00E+00	3.02E+02	1.95E-02	1.17E-03	1.95E-05	Sr-90	1.32E-03	1.27E-04	0.00E+00	1.45E-03
Cs-134	4.39E+00	7.33E-05	6.09E-05	4.55E-03	5.91E+03	7.04E+06	7.91E+01	3.00E+00	3.96E+02	2.41E-02	1.90E-03	7.22E-05	Cs-134	8.43E-04	4.69E-05	1.16E-07	8.90E-04
Cs-137	2.27E+00	5.00E-05	1.20E-05	5.50E-01	7.15E+05	8.52E+08	7.91E+01	3.00E+00	3.96E+02	2.91E+00	2.30E-01	8.73E-03	Cs-137	6.96E-02	2.94E-03	2.76E-06	7.25E-02
Co-60	6.58E+00	2.69E-05	6.30E-04	5.84E-02	7.59E+04	9.04E+07	1.28E+02	1.00E+02	6.40E+02	1.91E-01	2.45E-02	1.91E-02	Co-60	2.46E-03	5.60E-04	1.54E-05	3.04E-03
Co-57	1.67E-01	1.18E-06	2.80E-08	3.06E-04	3.98E+02	4.74E+05	1.28E+02	1.00E+02	6.40E+02	1.00E-03	1.28E-04	1.00E-04	Co-57	5.66E-07	7.45E-08	3.59E-12	6.41E-07
Fe-55	2.50E-03	6.07E-07	0.00E+00	4.81E-03	6.25E+03	7.45E+06	2.50E+01	1.00E+02	1.26E+02	7.99E-02	2.00E-03	7.99E-03	Fe-55	2.32E-05	8.88E-08	0.00E+00	2.33E-05
H-3	2.27E-01	6.40E-08	0.00E+00	2.36E-02	3.06E+04	3.64E+07	0.00E+00	0.00E+00	1.00E+00	4.94E+01	0.00E+00	0.00E+00	H-3	1.51E-03	4.98E-03	0.00E+00	6.49E-03
Ni-63	1.19E-02	5.77E-07	0.00E+00	3.55E-01	4.61E+05	5.50E+08	1.28E+02	1.00E+02	6.40E+02	1.16E+00	1.49E-01	1.16E-01	Ni-63	3.21E-04	6.16E-06	0.00E+00	3.27E-04
					1.30E+06	1.55E+09											
													SUM	7.60E-02	8.66E-03	1.83E-05	8.47E-02

**(Containment)  
Special Areas**

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**CONTAMINATED CONCRETE SPECIAL AREAS**

**Key Parameters:**

Porosity	0.30		Concrete Density	2.20	g/cm <sup>3</sup>	
Bulk Density	1.50	g/cm <sup>3</sup>	Annual Total Well Water Vol	738.0	m <sup>3</sup>	
Yearly Drinking Water	478.0	L/yr	Irrigation Rate	0.274	L/m <sup>2</sup> -d	
Wall Surface Area	1131.6	m <sup>2</sup>	Surface Soil Depth	0.15	m	8.15E-02 <== Total Dose Contaminated Concrete
Fill Volume	2460.0	m <sup>3</sup>	Special Areas Gross Beta DCGL	9.50E+03	dpm/100 cm <sup>2</sup>	
Surface Area/Open Volume	0.46	m <sup>2</sup> /m <sup>3</sup>	Gross Beta Nuclide Fraction	0.6672		2.92E-02 <== Total Dose Special Areas
Concrete Volume	1.13	m <sup>3</sup>	Total Inventory	1.42E+04	dpm/100 cm <sup>2</sup>	

DOSE CALCULATION FACTORS				SOURCE TERM			Kd		WATER, FILL, CONCRETE CONCENTRATION				CONTAMINATED CONCRETE ANNUAL DOSE				
Nuclide	NUREG-1727 mrem/y per pCi/g	FGR 11 mrem/pCi	Microshield mrem/y per pCi/g	Nuclide Fraction	Inventory dpm/100 cm <sup>2</sup>	Inventory pCi	Kd Fill cm <sup>3</sup> /gm	Kd Concrete cm <sup>3</sup> /gm	Adsorption Factor	Water pCi/L	Fill pCi/g	Concrete pCi/g	Nuclide	Drinking Water Dose mrem/y	Irrigation Dose mrem/y	Direct Dose mrem/y	Total Dose mrem/y
Sr-90	1.47E+01	1.42E-04	0.00E+00	6.874E-03	9.79E+01	4.99E+06	6.12E+01	1.00E+00	3.07E+02	2.20E-02	1.35E-03	2.20E-05	Sr-90	1.50E-03	1.44E-04	0.00E+00	1.64E-03
Sb-125	9.77E-01	2.81E-06	3.83E-06	4.523E-03	6.44E+01	3.28E+06	4.50E+01	0.00E+00	2.26E+02	1.97E-02	8.86E-04	0.00E+00	Sb-125	2.64E-05	8.55E-06	3.39E-09	3.50E-05
Cs-134	4.39E+00	7.33E-05	6.09E-05	2.815E-03	4.01E+01	2.04E+06	7.91E+01	3.00E+00	3.96E+02	6.98E-03	5.52E-04	2.09E-05	Cs-134	2.45E-04	1.36E-05	3.36E-08	2.58E-04
Cs-137	2.27E+00	5.00E-05	1.20E-05	2.890E-01	4.12E+03	2.10E+08	7.91E+01	3.00E+00	3.96E+02	7.17E-01	5.67E-02	2.15E-03	Cs-137	1.71E-02	7.23E-04	6.80E-07	1.79E-02
Pu-238	1.00E+01	3.20E-03	2.45E-25	1.165E-04	1.66E+00	8.46E+04	5.50E+02	5.00E+03	2.77E+03	4.14E-05	2.28E-05	2.07E-04	Pu-238	6.33E-05	1.84E-07	5.58E-30	6.35E-05
Pu-239	1.09E+01	3.54E-03	6.10E-15	8.752E-05	1.25E+00	6.35E+04	5.50E+02	5.00E+03	2.77E+03	3.11E-05	1.71E-05	1.55E-04	Pu-239	5.26E-05	1.51E-07	1.04E-19	5.28E-05
Pu-240	1.09E+01	3.54E-03	7.52E-26	8.750E-05	1.25E+00	6.35E+04	5.50E+02	5.00E+03	2.77E+03	3.11E-05	1.71E-05	1.55E-04	Pu-240	5.26E-05	1.51E-07	1.29E-30	5.28E-05
Pu-241	3.47E-01	6.85E-05	0.00E+00	6.705E-03	9.55E+01	4.87E+06	5.50E+02	5.00E+03	2.77E+03	2.38E-03	1.31E-03	1.19E-02	Pu-241	7.80E-05	3.67E-07	0.00E+00	7.84E-05
Am-241	1.19E+01	3.64E-03	1.65E-19	5.929E-04	8.44E+00	4.30E+05	1.90E+03	5.00E+03	9.51E+03	6.13E-05	1.16E-04	3.06E-04	Am-241	1.07E-04	3.24E-07	1.93E-23	1.07E-04
Cm-243	7.81E+00	2.51E-03	1.27E-08	4.649E-05	6.62E-01	3.37E+04	4.00E+03	5.00E+03	2.00E+04	2.28E-06	9.14E-06	1.14E-05	Cm-243	2.74E-06	7.93E-09	1.16E-13	2.75E-06
Cm-244	6.00E+00	2.02E-03	9.81E-25	4.454E-05	6.34E-01	3.23E+04	4.00E+03	5.00E+03	2.00E+04	2.19E-06	8.75E-06	1.09E-05	Cm-244	2.11E-06	5.84E-09	8.59E-30	2.12E-06
Co-60	6.58E+00	2.69E-05	6.30E-04	3.639E-01	5.18E+03	2.64E+08	1.28E+02	1.00E+02	6.40E+02	5.59E-01	7.14E-02	5.59E-02	Co-60	7.19E-03	1.64E-03	4.50E-05	8.87E-03
Co-57	1.67E-01	1.18E-06	2.80E-08		0.00E+00	0.00E+00	1.28E+02	1.00E+02	6.40E+02	0.00E+00	0.00E+00	0.00E+00	Co-57	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mn-54	1.67E+00	2.77E-06	4.40E-05	4.028E-04	5.74E+00	2.92E+05	5.00E+01	0.00E+00	2.51E+02	1.58E-03	7.89E-05	0.00E+00	Mn-54	2.09E-06	1.17E-06	3.47E-09	3.26E-06
Fe-55	2.50E-03	6.07E-07	0.00E+00	2.235E-02	3.18E+02	1.62E+07	2.50E+01	1.00E+02	1.26E+02	1.74E-01	4.35E-03	1.74E-02	Fe-55	5.05E-05	1.93E-07	0.00E+00	5.07E-05
H-3	2.27E-01	6.40E-08	0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	0.00E+00	0.00E+00	0.00E+00	H-3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ni-63	1.19E-02	5.77E-07	0.00E+00	3.024E-01	4.31E+03	2.19E+08	1.28E+02	1.00E+02	6.40E+02	4.65E-01	5.94E-02	4.65E-02	Ni-63	1.28E-04	2.46E-06	0.00E+00	1.31E-04
													SUM	2.66E-02	2.53E-03	4.57E-05	2.92E-02

**(Non-Containment)  
Contaminated Concrete**

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**CONTAMINATED CONCRETE**

**Key Parameters:**

Porosity	0.30		Concrete Density	2.20	g/cm <sup>3</sup>
Bulk Density	1.50	g/cm <sup>3</sup>	Annual Total Well Water Vol	738.0	m <sup>3</sup>
Yearly Drinking Water	478.0	L/yr	Irrigation Rate	0.274	L/m <sup>2</sup> -d
Wall Surface Area	4182.0	m <sup>2</sup>	Surface Soil Depth	0.15	m
Fill Volume	2460.0	m <sup>3</sup>	Gross Beta DCGL	1.80E+04	dpm/100 cm <sup>2</sup>
Surface Area/Open Volume	1.70	m <sup>2</sup> /m <sup>3</sup>	Gross Beta Nuclide Fraction	0.6160	
Concrete Volume	4.18	m <sup>3</sup>	Total Inventory	2.92E+04	dpm/100 cm <sup>2</sup>

DOSE CALCULATION FACTORS				SOURCE TERM			Kd		WATER, FILL, CONCRETE CONCENTRATION				CONTAMINATED CONCRETE ANNUAL DOSE				
Nuclide	NUREG-1727 mrem/y per pCi/g	FGR 11 mrem/pCi	Microshield mrem/y per pCi/g	Nuclide Fraction	Inventory dpm/100 cm <sup>2</sup>	Inventory pCi	Kd Fill cm <sup>3</sup> /gm	Kd Concrete cm <sup>3</sup> /gm	Adsorption Factor	Water pCi/L	Fill pCi/g	Concrete pCi/g	Nuclide	Drinking Water Dose mrem/y	Irrigation Dose mrem/y	Direct Dose mrem/y	Total Dose mrem/y
Sr-90	1.47E+01	1.42E-04	0.00E+00	2.80E-03	8.19E+01	1.54E+07	6.02E+01	1.00E+00	3.01E+02	6.93E-02	4.17E-03	6.93E-05	Sr-90	4.70E-03	4.52E-04	0.00E+00	5.15E-03
Cs-134	4.39E+00	7.33E-05	6.09E-05	4.55E-03	1.33E+02	2.50E+07	7.91E+01	3.00E+00	3.96E+02	8.55E-02	6.77E-03	2.57E-04	Cs-134	3.00E-03	1.67E-04	4.12E-07	3.16E-03
Cs-137	2.27E+00	5.00E-05	1.20E-05	5.50E-01	1.61E+04	3.03E+09	7.91E+01	3.00E+00	3.96E+02	1.03E+01	8.19E-01	3.10E-02	Cs-137	2.47E-01	1.04E-02	9.82E-06	2.58E-01
Co-60	6.58E+00	2.69E-05	6.30E-04	5.84E-02	1.71E+03	3.22E+08	1.28E+02	1.00E+02	6.40E+02	6.80E-01	8.68E-02	6.80E-02	Co-60	8.74E-03	1.99E-03	5.47E-05	1.08E-02
Co-57	1.67E-01	1.18E-06	2.80E-08	3.06E-04	8.95E+00	1.69E+06	1.28E+02	1.00E+02	6.40E+02	3.57E-03	4.56E-04	3.57E-04	Co-57	2.01E-06	2.65E-07	1.28E-11	2.28E-06
Fe-55	2.50E-03	6.07E-07	0.00E+00	4.81E-03	1.41E+02	2.65E+07	2.50E+01	1.00E+02	1.27E+02	2.82E-01	7.05E-03	2.82E-02	Fe-55	8.19E-05	3.14E-07	0.00E+00	8.22E-05
H-3	2.27E-01	6.40E-08	0.00E+00	2.36E-02	6.88E+02	1.30E+08	0.00E+00	0.00E+00	1.00E+00	1.75E+02	0.00E+00	0.00E+00	H-3	5.36E-03	1.77E-02	0.00E+00	2.31E-02
Ni-63	1.19E-02	5.77E-07	0.00E+00	3.55E-01	1.04E+04	1.96E+09	1.28E+02	1.00E+02	6.40E+02	4.13E+00	5.28E-01	4.13E-01	Ni-63	1.14E-03	2.19E-05	0.00E+00	1.16E-03
													SUM	2.70E-01	3.08E-02	6.49E-05	3.01E-01

**(Non-Containment)  
Surface Soil**

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**SURFACE SOIL**

**Key Parameters:**

Soil Depth	0.15	m
Surface Soil (Cs-137) Concentration	2.39	pCi/g
Surface Soil Total Concentration	2.69	pCi/g

DOSE CALCULATION FACTORS		SOURCE TERM		SURFACE SOIL ANNUAL DOSE
Nuclide	NUREG-1727 mrem/y per pCi/g	Nuclide Fraction	Soil pCi/g	Total Dose mrem/y
Cs-137	2.27E+00	8.90E-01	2.39E+00	5.43E+00
Co-60	6.58E+00	9.00E-03	2.42E-02	1.59E-01
H-3	2.27E-01	5.30E-02	1.43E-01	3.24E-02
Ni-63	1.19E-02	4.80E-02	1.29E-01	1.54E-03
SUM				5.63E+00

8/14/03

**(Non-Containment)  
Activated Concrete**

Attachment 6-13  
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**ACTIVATED CONCRETE (50 yr Liner Breach and Diffusion)**

**Key Parameters:**

Porosity	0.30		Concrete Density	2.20	g/cm <sup>3</sup>
Bulk Density	1.50	g/cm <sup>3</sup>	Annual Total Well Water Vol	738.0	m <sup>3</sup>
Yearly Drinking Water	478.0	L/yr	Irrigation Rate	0.274	L/m <sup>2</sup> -d
Wall Surface Area	4182.0	m <sup>2</sup>	Surface Soil Depth	0.15	m
Fill Volume	2460.0	m <sup>3</sup>	Activated Concrete Total Inventory	0.00E+00	pCi
Surface Area/Open Volume	1.70	m <sup>2</sup> /m <sup>3</sup>			
Concrete Volume	4.18	m <sup>3</sup>			

DOSE CALCULATION FACTORS				SOURCE TERM		Kd		WATER, FILL, CONCRETE CONCENTRATION				ACTIVATED CONCRETE ANNUAL DOSE				
Nuclide	NUREG-1727 mrem/y per pCi/g	FGR 11 mrem/pCi	Microshield mrem/y per pCi/g	Nuclide Fraction	Inventory pCi	Kd Fill cm <sup>3</sup> /gm	Kd Concrete cm <sup>3</sup> /gm	Adsorption Factor	Water pCi/L	Fill pCi/g	Concrete pCi/g	Nuclide	Drinking Water Dose mrem/y	Irrigation Dose mrem/y	Direct Dose mrem/y	Total Dose mrem/y
Cs-134	4.39E+00	7.33E-05	6.09E-05	5.72E-03	0.00E+00	7.91E+01	3.00E+00	3.96E+02	0.00E+00	0.00E+00	0.00E+00	Cs-134	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Co-60	6.58E+00	2.69E-05	6.30E-04	2.73E-02	0.00E+00	1.28E+02	1.00E+02	6.40E+02	0.00E+00	0.00E+00	0.00E+00	Co-60	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C-14	2.08E+00	2.09E-06	0.00E+00	1.48E-01	0.00E+00	5.00E+00	1.00E+02	2.72E+01	0.00E+00	0.00E+00	0.00E+00	C-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Eu-154	3.13E+00	9.55E-06	3.10E-04	6.10E-03	0.00E+00	4.00E+02	5.00E+03	2.06E+03	0.00E+00	0.00E+00	0.00E+00	Eu-154	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Fe-55	2.50E-03	6.07E-07	0.00E+00	8.44E-02	0.00E+00	2.50E+01	1.00E+02	1.27E+02	0.00E+00	0.00E+00	0.00E+00	Fe-55	0.00E+00	0.00E+00	0.00E+00	0.00E+00
H-3	2.27E-01	6.40E-08	0.00E+00	4.41E-01	0.00E+00	0.00E+00	0.00E+00	1.00E+00	0.00E+00	0.00E+00	0.00E+00	H-3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Eu-152	2.87E+00	6.48E-06	2.09E-04	7.56E-02	0.00E+00	4.00E+02	5.00E+03	2.06E+03	0.00E+00	0.00E+00	0.00E+00	Eu-152	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ni-63	1.19E-02	5.77E-07	0.00E+00	2.11E-01	0.00E+00	1.28E+02	1.00E+02	6.40E+02	0.00E+00	0.00E+00	0.00E+00	Ni-63	0.00E+00	0.00E+00	0.00E+00	0.00E+00
				9.99E-01	0.00E+00							SUM	0.00E+00	0.00E+00	0.00E+00	0.00E+00

**(Non-Containment)  
Activated Rebar**

Attachment 6-13  
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**Activated Rebar**

**Key Parameters:**

Porosity	0.30		Concrete Density	2.20	g/cm <sup>3</sup>
Bulk Density	1.50	g/cm <sup>3</sup>	Annual Total Well Water Vol	738.0	m <sup>3</sup>
Yearly Drinking Water	478.0	L/yr	Irrigation Rate	0.274	L/m <sup>2</sup> -d
Wall Surface Area	4182.0	m <sup>2</sup>	Surface Soil Depth	0.15	m
Fill Volume	2460.0	m <sup>3</sup>	Activated Concrete Total Inventory	0.00E+00	pCi (1.9*Activated Concrete Inventory)
Surface Area/Open Volume	1.70	m <sup>2</sup> /m <sup>3</sup>			
Concrete Volume	4.18	m <sup>3</sup>			

DOSE CALCULATION FACTORS				SOURCE TERM		Kd		WATER, FILL, CONCRETE CONCENTRATION				ACTIVATED REBAR ANNUAL DOSE				
Nuclide	NUREG-1727	FGR 11	Microshield	Nuclide	Inventory	Kd	Kd	Adsorption	Water	Fill	Concrete	Nuclide	Drinking	Irrigation	Direct	Total
	mrem/y per pCi/g	mrem/pCi	mrem/y per pCi/g										Water Dose mrem/y	Dose mrem/y	Dose mrem/y	Dose mrem/y
Cs-134	4.39E+00	7.33E-05	6.09E-05	0.00E+00	0.00E+00	7.91E+01	3.00E+00	3.98E+02	0.00E+00	0.00E+00	0.00E+00	Cs-134	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Co-60	6.58E+00	2.69E-05	6.30E-04	3.00E-02	0.00E+00	1.28E+02	1.00E+02	6.40E+02	0.00E+00	0.00E+00	0.00E+00	Co-60	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C-14	2.08E+00	2.09E-06	0.00E+00	0.00E+00	0.00E+00	5.00E+00	1.00E+02	2.72E+01	0.00E+00	0.00E+00	0.00E+00	C-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Eu-154	3.13E+00	9.55E-06	3.10E-04	0.00E+00	0.00E+00	4.00E+02	5.00E+03	2.06E+03	0.00E+00	0.00E+00	0.00E+00	Eu-154	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Fe-55	2.50E-03	6.07E-07	0.00E+00	8.18E-04	0.00E+00	2.50E+01	1.00E+02	1.27E+02	0.00E+00	0.00E+00	0.00E+00	Fe-55	0.00E+00	0.00E+00	0.00E+00	0.00E+00
H-3	2.27E-01	6.40E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	0.00E+00	0.00E+00	0.00E+00	H-3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Eu-152	2.87E+00	6.48E-06	2.08E-04	0.00E+00	0.00E+00	4.00E+02	5.00E+03	2.06E+03	0.00E+00	0.00E+00	0.00E+00	Eu-152	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ni-63	1.19E-02	5.77E-07	0.00E+00	9.69E-01	0.00E+00	1.28E+02	1.00E+02	6.40E+02	0.00E+00	0.00E+00	0.00E+00	Ni-63	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SUM													0.00E+00	0.00E+00	0.00E+00	0.00E+00

**(Non-Containment)  
Deep Soil**

**DEEP SOIL**

**Key Parameters:**

Porosity	0.3		Surface Soil Depth	0.15	m
Bulk Density	1.6	g/cm <sup>3</sup>	Deep Soil (Cs-137) Concentration	(Limited to 2.39)	4.31 pCi/g
Yearly Drinking Water	478	L/y	Deep Soil Total Concentration		4.83 pCi/g
Irrigation Rate	0.274	L/m <sup>2</sup> -d			

Using ResRad results for pCi/L per pCi/g conversion Table 1 of EC-018-01 half sand half gravel(.44) 6/18/02

DOSE CALCULATION FACTORS				SOURCE TERM				DEEP SOIL ANNUAL DOSE			
Nuclide	NUREG-1727 mrem/y per pCi/g	FGR 11 mrem/pCi	Microshield mrem/y per pCi/g	Nuclide Fraction	Deep Soil Inventory pCi/g	Derived Water Conversion Units pCi/L per pCi/g	Water Inventory pCi/L	Drinking Water Dose mrem/y	Irrigation Dose mrem/y	Direct Dose mrem/y	Total Dose mrem/y
Cs-137	2.27E+00	5.00E-05	4.00E-01	8.90E-01	4.30E+00	9.02E-03	3.87E-02	9.26E-04	3.66E-05	1.72E+00	1.72E+00
Co-60	6.58E+00	2.69E-05	2.40E+00	9.00E-03	4.34E-02	2.24E-02	9.74E-04	1.25E-05	2.67E-06	1.04E-01	1.04E-01
H-3	2.27E-01	6.40E-08	0.00E+00	5.30E-02	2.56E-01	6.69E+03	1.71E+03	5.23E-02	1.62E-01	0.00E+00	2.14E-01
Ni-63	1.19E-02	5.77E-07	0.00E+00	4.80E-02	2.32E-01	6.01E-01	1.39E-01	3.84E-05	6.90E-07	0.00E+00	3.91E-05
								5.33E-02	1.62E-01	1.82E+00	2.04E+00

1/11/2005

**(Non-Containment)  
Ground Water**

**Attachment 6-13  
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**GROUND WATER**

**Key Parameters:**

Annual Water Intake      478   L/y

Dose Calculation Factors		Source Term		Ground Water Annual Dose	
Nuclide	FGR 11 mrem/pCi	Nuclide Fraction	Inventory pCi/L	Drinking Water Dose mrem/y	
H-3	6.40E-08	1.00E+00	6,812	2.08E-01	
SUM				2.08E-01	

8/30/02



**(Non-Containment)  
Surface Water**

**Attachment 6-13  
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**SURFACE WATER**

**Key Parameters:**

Annual Water Intake	478	L/y
Annual Fish Consumption	20.6	Kg/y

Dose Calculation factors			Source Term		Surface Water Annual Dose		
Nuclide	FGR 11 mrem/pCi	Bioaccumulation Factor for Fish pCi/Kg per pCi/L	Nuclide Fraction	Water Inventory pCi/L	Drinking Water Dose mrem/y	Fish Ingestion Dose mrem/y	Total Dose mrem/y
H-3	6.40E-08	1.00E+00	1.00E+00	960	2.94E-02	1.27E-03	3.06E-02
				SUM	2.94E-02	1.27E-03	3.06E-02

**(Non-Containment)  
Buried Piping**

Attachment 6-13  
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**BURIED PIPING**

**Key Parameters:**

Porosity	0.3	Buried Pipe Conversion Factor	2.59E-04	pCi/g per dpm/100 cm <sup>2</sup>
Bulk Density	1.6 g/cm <sup>3</sup>	Gross Beta DCGL	9.80E+03	dpm/100 cm <sup>2</sup>
Yearly Drinking Water	478 L/y	Gross Beta Nuclide Fraction	0.616	
Irrigation Rate	0.274 L/m <sup>2</sup> -d	Total Inventory	1.59E+04	dpm/100 cm <sup>2</sup>
Surface Soil Depth	0.15 m			

Dose Calculation Factors				Source Term				Buried Piping Annual Dose			
Nuclide	FGR 11 mrem/pCi	NUREG-1727 mrem/y per pCi/g	Microshield mrem/y per pCi/g	Nuclide Fraction	Water Inventory pCi/L per pCi/g	Pipe Surface Inventory dpm/100cm <sup>2</sup>	Soil Inventory pCi/g	Drinking Water Dose mrem/y	Irrigation Dose mrem/y	Direct Dose mrem/y	Total Dose mrem/y
Sr-90	1.42E-04	1.47E+01	0.00E+00	2.80E-03	2.15E-02	4.46E+01	1.15E-02	1.68E-05	1.52E-06	0.00E+00	1.83E-05
Cs-134	7.33E-05	4.39E+00	2.21E-05	4.55E-03	2.25E-05	7.23E+01	1.87E-02	1.48E-08	7.71E-10	4.14E-07	4.30E-07
Cs-137	5.00E-05	2.27E+00	3.97E-06	5.50E-01	3.27E-04	8.75E+03	2.27E+00	1.77E-05	7.01E-07	9.01E-06	2.74E-05
Co-60	2.69E-05	6.58E+00	2.53E-04	5.84E-02	8.14E-04	9.29E+02	2.41E-01	2.52E-06	5.37E-07	6.09E-05	6.40E-05
Co-57	1.18E-06	1.67E-01	9.44E-09	3.06E-04	1.15E-04	4.88E+00	1.26E-03	8.18E-11	1.01E-11	1.19E-11	1.04E-10
Fe-55	6.07E-07	2.50E-03	0.00E+00	4.81E-03	4.30E-05	7.66E+01	1.98E-02	2.47E-10	8.89E-13	0.00E+00	2.48E-10
H-3	6.40E-08	2.27E-01	0.00E+00	2.36E-02	1.98E+02	3.75E+02	9.70E-02	5.88E-04	1.82E-03	0.00E+00	2.41E-03
Ni-63	5.77E-07	1.19E-02	0.00E+00	3.55E-01	2.09E-02	5.65E+03	1.46E+00	8.42E-06	1.51E-07	0.00E+00	8.57E-06
						<b>SUM</b>		6.33E-04	1.82E-03	7.03E-05	2.52E-03

**(Non-Containment)  
BOP Embedded Piping**

Attachment 6-13  
Page 22 of 24

**BOP EMBEDDED PIPE**

**Key Parameters:**

Porosity	0.30		Concrete Density	2.20	g/cm <sup>3</sup>
Bulk Density	1.50	g/cm <sup>3</sup>	Surface Soil Depth	0.15	m
Yearly Drinking Water	478.0	l/yr	Irrigation Rate	0.274	L/m <sup>2</sup> -d
Wall Surface Area	4182.0	m <sup>2</sup>	Annual Total Well Water Vol	738	m <sup>3</sup>
Fill Volume	2460.0	m <sup>3</sup>	Embedded Pipe Conversion Factor	5754.5	pCi per dpm/100 cm <sup>2</sup>
Surface Area/Open Volume	1.70	m <sup>2</sup> /m <sup>3</sup>	Gross Beta DCGL	1.00E+05	dpm/100 cm <sup>2</sup>
Concrete Volume	4.18	m <sup>3</sup>	Gross Beta Nuclide Fraction	0.616	
			Total Inventory	1.62E+05	dpm/100 cm <sup>2</sup>

DOSE CALCULATION FACTORS				SOURCE TERM			Kd		WATER, FILL, CONCRETE CONCENTRATION				EMBEDDED PIPE ANNUAL DOSE				
Nuclide	NUREG-1727	FGR 11	Microshield	Fraction	Inventory	Inventory	Kd	Kd	Adsorption	Water	Fill	Concrete	Nuclide	Drinking	Irrigation	Direct	Total
	mrem/y per pCi/g	mrem/pCi	mrem/y per pCi/g		dpm/100 cm <sup>2</sup>	pCi	cm <sup>3</sup> /gm	cm <sup>3</sup> /gm						Factor	pCi/L	pCi/g	pCi/g
														mrem/y	mrem/y	mrem/y	mrem/y
Sr-90	1.47E+01	1.42E-04	0.00E+00	2.80E-03	4.55E+02	2.62E+06	6.02E+01	1.00E+00	3.01E+02	1.18E-02	7.07E-04	1.18E-05	Sr-90	7.98E-04	7.68E-05	0.00E+00	8.75E-04
Cs-134	4.39E+00	7.33E-05	6.09E-05	4.55E-03	7.38E+02	4.25E+06	7.91E+01	3.00E+00	3.96E+02	1.45E-02	1.15E-03	4.36E-05	Cs-134	5.09E-04	2.83E-05	6.99E-08	5.37E-04
Cs-137	2.27E+00	5.00E-05	1.20E-05	5.50E-01	8.93E+04	5.14E+08	7.91E+01	3.00E+00	3.96E+02	1.76E+00	1.39E-01	5.27E-03	Cs-137	4.20E-02	1.77E-03	1.67E-06	4.38E-02
Co-60	6.58E+00	2.69E-05	6.30E-04	5.84E-02	9.48E+03	5.46E+07	1.28E+02	1.00E+02	6.40E+02	1.15E-01	1.47E-02	1.15E-02	Co-60	1.48E-03	3.37E-04	9.29E-06	1.83E-03
Co-57	1.67E-01	1.18E-06	2.80E-08	3.06E-04	4.97E+01	2.86E+05	1.28E+02	1.00E+02	6.40E+02	6.05E-04	7.73E-05	6.05E-05	Co-57	3.41E-07	4.49E-08	2.16E-12	3.86E-07
Fe-55	2.50E-03	6.07E-07	0.00E+00	4.81E-03	7.82E+02	4.50E+06	2.50E+01	1.00E+02	1.27E+02	4.79E-02	1.20E-03	4.79E-03	Fe-55	1.39E-05	5.32E-08	0.00E+00	1.39E-05
H-3	2.27E-01	6.40E-08	0.00E+00	2.36E-02	3.82E+03	2.20E+07	0.00E+00	0.00E+00	1.00E+00	2.98E+01	0.00E+00	0.00E+00	H-3	9.10E-04	3.00E-03	0.00E+00	3.91E-03
Ni-63	1.19E-02	5.77E-07	0.00E+00	3.55E-01	5.77E+04	3.32E+08	1.28E+02	1.00E+02	6.40E+02	7.01E-01	8.96E-02	7.01E-02	Ni-63	1.93E-04	3.71E-06	0.00E+00	1.97E-04
SUM														4.59E-02	5.22E-03	1.10E-05	5.11E-02

**(Non-Containment)**  
**Spray Building Embedded Pump Piping**

Attachment 6-13  
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**EMBEDDED SPRAY PUMP PIPING**

**Key Parameters:**

Porosity	0.30		Concrete Density	2.20	g/cm <sup>3</sup>
Bulk Density	1.50	g/cm <sup>3</sup>	Surface Soil Depth	0.15	m
Yearly Drinking Water	478.0	l/yr	Irrigation Rate	0.274	L/m <sup>2</sup> -d
Wall Surface Area	4182.0	m <sup>2</sup>	Annual Total Well Water Vol.	738	m <sup>3</sup>
Fill Volume	2460.0	m <sup>3</sup>	Embedded Pipe Conversion Factor	1191.7	pCi per dpm/100 cm <sup>2</sup>
Surface Area/Open Volume	1.70	m <sup>2</sup> /m <sup>3</sup>	Gross Beta DCGL	8.00E+05	dpm/100 cm <sup>2</sup>
Concrete Volume	4.18	m <sup>3</sup>	Gross Beta Nuclide Fraction	0.616	
			Total Inventory	1.30E+06	dpm/100 cm <sup>2</sup>

DOSE CALCULATION FACTORS				SOURCE TERM			Kd		WATER, FILL, CONCRETE CONCENTRATION				EMBEDDED PIPE ANNUAL DOSE				
Nuclide	NUREG-1727	FGR 11	Microshield	Fraction	Inventory dpm/100 cm <sup>2</sup>	Inventory pCi	Kd Fill cm <sup>3</sup> /gm	Kd Concrete cm <sup>3</sup> /gm	Adsorption Factor	Water pCi/L	Fill pCi/g	Concrete pCi/g	Nuclide	Drinking	Irrigation	Direct	Total
	mrem/y per pCi/g	mrem/pCi	mrem/y per pCi/g											Water Dose mrem/y	Dose mrem/y	Dose mrem/y	Dose mrem/y
Sr-90	1.47E+01	1.42E-04	0.00E+00	2.80E-03	3.64E+03	4.34E+06	6.02E+01	1.00E+00	3.01E+02	1.95E-02	1.17E-03	1.95E-05	Sr-90	1.32E-03	1.27E-04	0.00E+00	1.45E-03
Cs-134	4.39E+00	7.33E-05	6.09E-05	4.55E-03	5.91E+03	7.04E+06	7.91E+01	3.00E+00	3.96E+02	2.41E-02	1.90E-03	7.22E-05	Cs-134	8.43E-04	4.69E-05	1.16E-07	8.90E-04
Cs-137	2.27E+00	5.00E-05	1.20E-05	5.50E-01	7.15E+05	8.52E+08	7.91E+01	3.00E+00	3.96E+02	2.91E+00	2.30E-01	8.73E-03	Cs-137	6.95E-02	2.94E-03	2.76E-06	7.25E-02
Co-60	6.58E+00	2.69E-05	6.30E-04	5.84E-02	7.59E+04	9.04E+07	1.28E+02	1.00E+02	6.40E+02	1.91E-01	2.44E-02	1.91E-02	Co-60	2.46E-03	5.59E-04	1.54E-05	3.03E-03
Co-57	1.67E-01	1.18E-06	2.80E-08	3.06E-04	3.98E+02	4.74E+05	1.28E+02	1.00E+02	6.40E+02	1.00E-03	1.28E-04	1.00E-04	Co-57	5.65E-07	7.44E-08	3.59E-12	6.40E-07
Fe-55	2.50E-03	6.07E-07	0.00E+00	4.81E-03	6.25E+03	7.45E+06	2.50E+01	1.00E+02	1.27E+02	7.93E-02	1.98E-03	7.93E-03	Fe-55	2.30E-05	8.82E-08	0.00E+00	2.31E-05
H-3	2.27E-01	6.40E-08	0.00E+00	2.36E-02	3.06E+04	3.64E+07	0.00E+00	0.00E+00	1.00E+00	4.93E+01	0.00E+00	0.00E+00	H-3	1.51E-03	4.97E-03	0.00E+00	6.48E-03
Ni-63	1.19E-02	5.77E-07	0.00E+00	3.55E-01	4.61E+05	5.50E+08	1.28E+02	1.00E+02	6.40E+02	1.16E+00	1.48E-01	1.16E-01	Ni-63	3.21E-04	6.15E-06	0.00E+00	3.27E-04
					1.30E+06	1.55E+09											
													SUM	7.60E-02	8.65E-03	1.83E-05	8.47E-02

**(Non-Containment)  
Special Areas**

Attachment 6-13  
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**CONTAMINATED CONCRETE SPECIAL AREAS**

**Key Parameters:**

Porosity	0.30		Concrete Density	2.20	g/cm <sup>3</sup>		
Bulk Density	1.50	g/cm <sup>3</sup>	Annual Total Well Water Vol	738.0	m <sup>3</sup>		
Yearly Drinking Water	478.0	L/yr	Irrigation Rate	0.274	L/m <sup>2</sup> -d		
Wall Surface Area	4182.0	m <sup>2</sup>	Surface Soil Depth	0.15	m	3.01E-01	<== Total Dose Contaminated Concrete
Fill Volume	2460.0	m <sup>3</sup>	Special Areas Gross Beta DCGL	9.50E+03	dpm/100 cm <sup>2</sup>		
Surface Area/Open Volume	1.70	m <sup>2</sup> /m <sup>3</sup>	Gross Beta Nuclide Fraction	0.6672		1.08E-01	<== Total Dose Special Areas
Concrete Volume	4.18	m <sup>3</sup>	Total Inventory	1.42E+04	dpm/100 cm <sup>2</sup>		

DOSE CALCULATION FACTORS				SOURCE TERM			Kd		WATER, FILL, CONCRETE CONCENTRATION				CONTAMINATED CONCRETE ANNUAL DOSE				
Nuclide	NUREG-1727 mrem/y per pCi/g	FGR 11 mrem/pCi	Microshield mrem/y per pCi/g	Nuclide Fraction	Inventory dpm/100 cm <sup>2</sup>	Inventory pCi	Kd Fill cm <sup>3</sup> /gm	Kd Concrete cm <sup>3</sup> /gm	Adsorption Factor	Water pCi/L	Fill pCi/g	Concrete pCi/g	Nuclide	Drinking Water Dose mrem/y	Irrigation Dose mrem/y	Direct Dose mrem/y	Total Dose mrem/y
Sr-90	1.47E+01	1.42E-04	0.00E+00	6.874E-03	9.79E+01	1.84E+07	6.12E+01	1.00E+00	3.06E+02	8.14E-02	4.98E-03	8.14E-05	Sr-90	5.53E-03	5.32E-04	0.00E+00	6.06E-03
Sb-125	9.77E-01	2.81E-06	3.83E-06	4.523E-03	6.44E+01	1.21E+07	4.50E+01	0.00E+00	2.26E+02	7.27E-02	3.27E-03	0.00E+00	Sb-125	9.77E-05	3.16E-05	1.25E-08	1.29E-04
Cs-134	4.39E+00	7.33E-05	6.09E-05	2.815E-03	4.01E+01	7.55E+06	7.91E+01	3.00E+00	3.96E+02	2.58E-02	2.04E-03	7.74E-05	Cs-134	9.04E-04	5.03E-05	1.24E-07	9.54E-04
Cs-137	2.27E+00	5.00E-05	1.20E-05	2.890E-01	4.12E+03	7.75E+08	7.91E+01	3.00E+00	3.96E+02	2.65E+00	2.10E-01	7.95E-03	Cs-137	6.33E-02	2.67E-03	2.51E-06	6.60E-02
Pu-238	1.00E+01	3.20E-03	2.45E-25	1.165E-04	1.66E+00	3.13E+05	5.50E+02	5.00E+03	2.81E+03	1.51E-04	8.28E-05	7.53E-04	Pu-238	2.30E-04	6.69E-07	2.03E-29	2.31E-04
Pu-239	1.09E+01	3.54E-03	6.10E-15	8.752E-05	1.25E+00	2.35E+05	5.50E+02	5.00E+03	2.81E+03	1.13E-04	6.22E-05	5.65E-04	Pu-239	1.91E-04	5.48E-07	3.79E-19	1.92E-04
Pu-240	1.09E+01	3.54E-03	7.52E-26	8.750E-05	1.25E+00	2.35E+05	5.50E+02	5.00E+03	2.81E+03	1.13E-04	6.22E-05	5.65E-04	Pu-240	1.91E-04	5.48E-07	4.68E-30	1.92E-04
Pu-241	3.47E-01	6.85E-05	0.00E+00	6.705E-03	9.55E+01	1.80E+07	5.50E+02	5.00E+03	2.81E+03	8.66E-03	4.76E-03	4.33E-02	Pu-241	2.84E-04	1.34E-06	0.00E+00	2.85E-04
Am-241	1.19E+01	3.64E-03	1.65E-19	5.929E-04	8.44E+00	1.59E+06	1.90E+03	5.00E+03	9.55E+03	2.25E-04	4.28E-04	1.13E-03	Am-241	3.92E-04	1.19E-06	7.08E-23	3.93E-04
Cm-243	7.81E+00	2.51E-03	1.27E-08	4.649E-05	6.62E-01	1.25E+05	4.00E+03	5.00E+03	2.00E+04	8.42E-06	3.37E-05	4.21E-05	Cm-243	1.01E-05	2.92E-08	4.28E-13	1.01E-05
Cm-244	6.00E+00	2.02E-03	9.81E-25	4.454E-05	6.34E-01	1.19E+05	4.00E+03	5.00E+03	2.00E+04	8.07E-06	3.23E-05	4.03E-05	Cm-244	7.79E-06	2.15E-08	3.17E-29	7.81E-06
Co-60	6.58E+00	2.69E-05	6.30E-04	3.639E-01	5.18E+03	9.76E+08	1.28E+02	1.00E+02	6.40E+02	2.06E+00	2.64E-01	2.06E-01	Co-60	2.65E-02	6.04E-03	1.66E-04	3.27E-02
Co-57	1.67E-01	1.18E-06	2.80E-08		0.00E+00	0.00E+00	1.28E+02	1.00E+02	6.40E+02	0.00E+00	0.00E+00	0.00E+00	Co-57	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mn-54	1.67E+00	2.77E-06	4.40E-05	4.028E-04	5.74E+00	1.08E+06	5.00E+01	0.00E+00	2.51E+02	5.83E-03	2.92E-04	0.00E+00	Mn-54	7.72E-06	4.33E-06	1.28E-08	1.21E-05
Fe-55	2.50E-03	6.07E-07	0.00E+00	2.235E-02	3.18E+02	6.00E+07	2.50E+01	1.00E+02	1.27E+02	6.38E-01	1.60E-02	6.38E-02	Fe-55	1.85E-04	7.09E-07	0.00E+00	1.86E-04
H-3	2.27E-01	6.40E-08	0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	0.00E+00	0.00E+00	0.00E+00	H-3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ni-63	1.19E-02	5.77E-07	0.00E+00	3.024E-01	4.31E+03	8.11E+08	1.28E+02	1.00E+02	6.40E+02	1.71E+00	2.19E-01	1.71E-01	Ni-63	4.73E-04	9.07E-06	0.00E+00	4.82E-04
SUM													SUM	9.83E-02	9.34E-03	1.69E-04	1.08E-01

**Attachment 6-14  
Soil Area Factor Microshield Output**

Attachment 6-14 illustrates the Microshield runs for determination of soil area factors. The associated Engineering Calculation for soil area factors provides all the Microshield runs used to derive the area factors for the Maine Yankee nuclide mixture, and mixtures containing 100 percent Co-60 and 100 percent Cs-137. These are presented in Section 6, Table 6-12 of the LTP. The runs illustrated in this attachment are for 100 percent Cs-137. These runs are the most conservative of the three area factor groups.

MicroShield v5.05 (5.05-00461)

Maine Yankee

REV 1, Att 3

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File Ref: \_\_\_\_\_

Date: \_\_\_\_\_

By: DBR

Checked: \_\_\_\_\_

Page : 1

DOS File : S10000CS.MS5

Run Date: May 17, 2002

Run Time: 7:06:32 AM

Duration : 00:00:02

Case Title: Soil AF 10,000 m<sup>2</sup>Description: Soil AF for CS-137 only, 1e4 m<sup>2</sup>

Geometry: 13 - Rectangular Volume

**Source Dimensions**

Length	15.0 cm	5.9 in
Width	1.0e+4 cm	328 ft 1.0 in
Height	1.0e+4 cm	328 ft 1.0 in

**Dose Points**

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	115 cm 3 ft 9.3 in	5000 cm 164 ft 0.5 in	5000 cm 164 ft 0.5 in

**Shields**

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	1.50e+09 cm <sup>3</sup>	soil (SiO <sub>2</sub> )	1.6
Air Gap		Air	0.00122

**Source Input****Grouping Method : Actual Photon Energies**

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>μCi/cm<sup>2</sup></u>	<u>Bq/cm<sup>2</sup></u>
Ba-137m	2.4000e-003	8.8800e+007	1.6000e-006	5.9200e-002
Cs-137	2.4000e-003	8.8800e+007	1.6000e-006	5.9200e-002

**Buildup**

The material reference is : Source

**Integration Parameters**

X Direction	10
Y Direction	20
Z Direction	20

**Results**

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.0318	1.838e+06	1.604e-05	2.373e-05	1.336e-07	1.977e-07
0.0322	3.392e+06	3.089e-05	4.611e-05	2.486e-07	3.711e-07
0.0364	1.234e+06	1.724e-05	2.857e-05	9.796e-08	1.623e-07
0.6616	7.990e+07	1.414e-01	3.078e-01	2.740e-04	5.968e-04



Rev 1, Att 3

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OS File : S10000CS.MS5

Jn Date: May 17, 2002

Jn Time: 7:06:32 AM

uration : 00:00:02

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
TOTALS:	8.637e+07	1.414e-01	3.079e-01	2.745e-04	5.975e-04

MicroShield v5.05 (5.05-00461)  
Maine Yankee

Rev 2, Att 3  
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Page : 1  
JOS File : S5000CS.MS5  
Run Date: May 17, 2002  
Run Time: 7:26:18 AM  
Duration : 00:00:02

File Ref: \_\_\_\_\_  
Date: \_\_\_\_\_  
By: DBR  
Checked: \_\_\_\_\_

Case Title: Soil AF 5,000 m<sup>2</sup>  
Description: Soil AF for Cs-137 only, 5e3 m<sup>2</sup>  
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	15.0 cm	5.9 in
Width	7.1e+3 cm	231 ft 11.9 in
Height	7.1e+3 cm	231 ft 11.9 in

Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	115 cm 3 ft 9.3 in	3536 cm 116 ft 0.1 in	3536 cm 116 ft 0.1 in

Shields

Shield Name	Dimension	Material	Density
Source	7.50e+08 cm <sup>3</sup>	soil (SiO <sub>2</sub> )	1.6
Air Gap		Air	0.00122

Source Input

Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm <sup>3</sup>	Bq/cm <sup>3</sup>
Ba-137m	1.2000e-003	4.4399e+007	1.6000e-006	5.9200e-002
Cs-137	1.2000e-003	4.4399e+007	1.6000e-006	5.9200e-002

Buildup

The material reference is : Source

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm <sup>2</sup> /sec No Buildup	Fluence Rate MeV/cm <sup>2</sup> /sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	9.192e+05	1.517e-05	2.248e-05	1.264e-07	1.873e-07
0.0322	1.696e+06	2.922e-05	4.368e-05	2.352e-07	3.516e-07
0.0364	6.171e+05	1.632e-05	2.711e-05	9.273e-08	1.540e-07
0.6616	3.995e+07	1.329e-01	2.914e-01	2.576e-04	5.648e-04

JOS File : S5000CS.MS5  
Run Date: May 17, 2002  
Run Time: 7:26:18 AM  
Duration : 00:00:02

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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
TOTALS:	4.318e+07	1.329e-01	2.914e-01	2.580e-04	5.655e-04

MicroShield v5.05 (5.05-00461)  
Maine Yankee

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Page : 1  
JOS File : S2500CS.MS5  
Run Date: May 17, 2002  
Run Time: 7:33:30 AM  
Duration : 00:00:02

File Ref: \_\_\_\_\_  
Date: \_\_\_\_\_  
By: DBR  
Checked: \_\_\_\_\_

Case Title: Soil AF 2,500 m<sup>2</sup>  
Description: Soil AF for Cs-137 only, 2.5e3 m<sup>2</sup>  
Geometry: 13 - Rectangular Volume



#### Source Dimensions

Length	15.0 cm	5.9 in
Width	5.0e+3 cm	164 ft 0.5 in
Height	5.0e+3 cm	164 ft 0.5 in

#### Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	115 cm 3 ft 9.3 in	2500 cm 82 ft 0.3 in	2500 cm 82 ft 0.3 in

#### Shields

Shield Name	Dimension	Material	Density
Source	3.75e+08 cm <sup>3</sup>	soil (SiO <sub>2</sub> )	1.6
Air Gap		Air	0.00122

#### Source Input

##### Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm <sup>3</sup>	Bq/cm <sup>3</sup>
Ba-137m	6.0000e-004	2.2200e+007	1.6000e-006	5.9200e-002
Cs-137	6.0000e-004	2.2200e+007	1.6000e-006	5.9200e-002

#### Buildup

The material reference is : Source

#### Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

#### Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm <sup>2</sup> /sec No Buildup	Fluence Rate MeV/cm <sup>2</sup> /sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	4.596e+05	1.440e-05	2.144e-05	1.199e-07	1.786e-07
0.0322	8.480e+05	2.774e-05	4.166e-05	2.233e-07	3.353e-07
0.0364	3.086e+05	1.551e-05	2.582e-05	8.815e-08	1.467e-07
0.6616	1.998e+07	1.272e-01	2.818e-01	2.465e-04	5.464e-04

DOS File : S2500CS.MS5  
Run Date: May 17, 2002  
Run Time: 7:33:30 AM  
Duration : 00:00:02

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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
TOTALS:	2.159e+07	1.272e-01	2.819e-01	2.469e-04	5.470e-04

MicroShield v5.05 (5.05-00105)  
Stone & Webster

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Page : 1  
DOS File: S2000CS.MS5  
Run Date: June 6, 2002  
Run Time: 8:48:53 AM  
Duration: 00:00:09

File Ref: \_\_\_\_\_

Date: \_\_\_\_\_

By: DR

Checked: \_\_\_\_\_

Case Title: Soil AF 2,000 m<sup>2</sup>  
Description: Soil AF for Cs-137 only, 2e3 m<sup>2</sup>  
Geometry: 13 - Rectangular Volume



## Source Dimensions

Length	15.0 cm	5.9 in
Width	4.5e+3 cm	146 ft 8.6 in
Height	4.5e+3 cm	146 ft 8.6 in

## Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	115 cm	2236 cm	2236 cm
	3 ft 9.3 in	73 ft 4.3 in	73 ft 4.3 in

## Shields

Shield Name	Dimension	Material	Density
Source	3.00e+08 cm <sup>3</sup>	soil (SiO <sub>2</sub> )	1.6
Air Gap		Air	0.00122

## Source Input

Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm <sup>3</sup>
Ba-137m	4.7997e-004	1.7759e+007	1.6000e-006	5.9200e-002
Cs-137	4.7997e-004	1.7759e+007	1.6000e-006	5.9200e-002

## Buildup

The material reference is : Source

## Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

## Results

Energy MeV	Activity photons/sec	Fluence Rate	Fluence Rate	Exposure Rate	Exposure Rate
		MeV/cm <sup>2</sup> /sec No Buildup	MeV/cm <sup>2</sup> /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.0318	3.677e+05	1.428e-05	2.126e-05	1.189e-07	1.771e-07
0.0322	6.783e+05	2.751e-05	4.130e-05	2.214e-07	3.324e-07
0.0364	2.468e+05	1.538e-05	2.560e-05	8.740e-08	1.454e-07
0.6616	1.598e+07	1.262e-01	2.800e-01	2.446e-04	5.428e-04
TOTALS:	1.727e+07	1.262e-01	2.801e-01	2.451e-04	5.435e-04

MicroShield v5.05 (5.05-00105)

Stone &amp; Webster

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Page : 1

DOS File: S1000CS.MS5

Run Date: June 6, 2002

Run Time: 8:50:07 AM

Duration: 00:00:09

File Ref: \_\_\_\_\_

Date: \_\_\_\_\_

By: DR

Checked: \_\_\_\_\_

Case Title: Soil AF 1,000 m<sup>2</sup>Description: Soil AF for Cs-137 only, 1e3 m<sup>2</sup>

Geometry: 13 - Rectangular Volume



## Source Dimensions

Length	15.0 cm	5.9 in
Width	3.2e+3 cm	103 ft 8.9 in
Height	3.2e+3 cm	103 ft 8.9 in

## Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	115 cm	1581 cm	1581 cm
	3 ft 9.3 in	51 ft 10.4 in	51 ft 10.4 in

## Shields

Shield Name	Dimension	Material	Density
Source	1.50e+08 cm <sup>3</sup>	soil (SiO <sub>2</sub> )	1.6
Air Gap		Air	0.00122

## Source Input

Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	$\mu$ Ci/cm <sup>3</sup>	Bq/cm <sup>3</sup>
Ba-137m	2.3996e-004	8.8784e+006	1.6000e-006	5.9200e-002
Cs-137	2.3996e-004	8.8784e+006	1.6000e-006	5.9200e-002

## Buildup

The material reference is : Source

## Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

## Results

Energy MeV	Activity photons/sec	Fluence Rate	Fluence Rate	Exposure Rate	Exposure Rate
		MeV/cm <sup>2</sup> /sec No Buildup	MeV/cm <sup>2</sup> /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.0318	1.838e+05	1.417e-05	2.108e-05	1.181e-07	1.756e-07
0.0322	3.391e+05	2.731e-05	4.095e-05	2.198e-07	3.295e-07
0.0364	1.234e+05	1.525e-05	2.534e-05	8.665e-08	1.439e-07
0.6616	7.989e+06	1.242e-01	2.749e-01	2.408e-04	5.329e-04
TOTALS:	8.635e+06	1.243e-01	2.750e-01	2.412e-04	5.336e-04

MicroShield v5.05 (5.05-00461)  
Maine Yankee

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Page : 1  
DOS File : S500CS.MS5  
Run Date: May 17, 2002  
Run Time: 8:02:12 AM  
Duration : 00:00:05

File Ref: \_\_\_\_\_  
Date: \_\_\_\_\_  
By: *DR*  
Checked: \_\_\_\_\_

Case Title: Soil AF 500 m<sup>2</sup>  
Description: Soil AF for Cs-137 only, 5e2 m<sup>2</sup>  
Geometry: 13 - Rectangular Volume



#### Source Dimensions

Length	15.0 cm	5.9 in
Width	2.2e+3 cm	73 ft 4.3 in
Height	2.2e+3 cm	73 ft 4.3 in

#### Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	115 cm 3 ft 9.3 in	1118 cm 36 ft 8.2 in	1118 cm 36 ft 8.2 in

#### Shields

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	7.50e+07 cm <sup>3</sup>	soil (SiO <sub>2</sub> )	1.6
Air Gap		Air	0.00122

#### Source Input

##### Grouping Method : Actual Photon Energies

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>μCi/cm<sup>3</sup></u>	<u>Bq/cm<sup>3</sup></u>
Ba-137m	1.1999e-004	4.4397e+006	1.6000e-006	5.9200e-002
Cs-137	1.1999e-004	4.4397e+006	1.6000e-006	5.9200e-002

#### Buildup

The material reference is : Source

#### Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

#### Results

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.0318	9.192e+04	1.414e-05	2.098e-05	1.178e-07	1.748e-07
0.0322	1.696e+05	2.723e-05	4.075e-05	2.192e-07	3.280e-07
0.0364	6.171e+04	1.515e-05	2.505e-05	8.607e-08	1.423e-07
0.6616	3.995e+06	1.216e-01	2.675e-01	2.357e-04	5.186e-04



DOS File : S500CS.MS5

Run Date: May 17, 2002

Run Time: 8:02:12 AM

Duration : 00:00:05

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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
TOTALS:	4.318e+06	1.216e-01	2.676e-01	2.361e-04	5.192e-04

MicroShield v5.05 (5.05-00461)  
Maine Yankee

Attachment 6-14

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File Ref: \_\_\_\_\_

Date: \_\_\_\_\_

By: DR

Checked: \_\_\_\_\_

Page : 1

JOS File : S300CS.MS5

Run Date: May 17, 2002

Run Time: 9:22:35 AM

Duration : 00:00:02

Case Title: Soil AF 300 m<sup>2</sup>  
Description: Soil AF for Cs-137 only, 3e2 m<sup>2</sup>  
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	15.0 cm	5.9 in
Width	1.7e+3 cm	56 ft 9.9 in
Height	1.7e+3 cm	56 ft 9.9 in

Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	115 cm 3 ft 9.3 in	866 cm 28 ft 4.9 in	866 cm 28 ft 4.9 in

Shields

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	4.50e+07 cm <sup>3</sup>	soil (SiO <sub>2</sub> )	1.6
Air Gap		Air	0.00122

Source Input

Grouping Method : Actual Photon Energies

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>μCi/cm<sup>3</sup></u>	<u>Bq/cm<sup>3</sup></u>
Ba-137m	7.1996e-005	2.6638e+006	1.6000e-006	5.9200e-002
Cs-137	7.1996e-005	2.6638e+006	1.6000e-006	5.9200e-002

Buildup

The material reference is : Source

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

Results

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.0318	5.515e+04	1.400e-05	2.071e-05	1.166e-07	1.725e-07
0.0322	1.018e+05	2.695e-05	4.018e-05	2.169e-07	3.233e-07
0.0364	3.703e+04	1.493e-05	2.456e-05	8.482e-08	1.396e-07
0.6616	2.397e+06	1.186e-01	2.596e-01	2.299e-04	5.033e-04

DOS File : S300CS.MS5

Run Date: May 17, 2002

Run Time: 9:22:35 AM

Duration : 00:00:02

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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
TOTALS:	2.591e+06	1.186e-01	2.597e-01	2.303e-04	5.039e-04

MicroShield v5.05 (5.05-00105)  
Stone & Webster

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Page : 1  
DOS File: S100CS.MS5  
Run Date: June 6, 2002  
Run Time: 8:52:09 AM  
Duration: 00:00:08

File Ref: \_\_\_\_\_  
Date: \_\_\_\_\_  
By: DR  
Checked: \_\_\_\_\_

Case Title: Soil AF 100 m<sup>2</sup>  
Description: Soil AF for Cs-137 only, 1e2 m<sup>2</sup>  
Geometry: 13 - Rectangular Volume



#### Source Dimensions

Length	15.0 cm	5.9 in
Width	1.0e+3 cm	32 ft 9.7 in
Height	1.0e+3 cm	32 ft 9.7 in

#### Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	115 cm	500 cm	500 cm
	3 ft 9.3 in	16 ft 4.9 in	16 ft 4.9 in

#### Shields

Shield Name	Dimension	Material	Density
Source	1.50e+07 cm <sup>3</sup>	soil (SiO2)	1.6
Air Gap		Air	0.00122

#### Source Input

Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm <sup>3</sup>
Ba-137m	2.4000e-005	8.8800e+005	1.6000e-006	5.9200e-002
Cs-137	2.4000e-005	8.8800e+005	1.6000e-006	5.9200e-002

#### Buildup

The material reference is : Source

#### Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

#### Results

Energy MeV	Activity photons/sec	Fluence Rate	Fluence Rate	Exposure Rate	Exposure Rate
		MeV/cm <sup>2</sup> /sec No Buildup	MeV/cm <sup>2</sup> /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.0318	1.838e+04	1.318e-05	1.930e-05	1.098e-07	1.607e-07
0.0322	3.392e+04	2.535e-05	3.739e-05	2.040e-07	3.009e-07
0.0364	1.234e+04	1.393e-05	2.266e-05	7.913e-08	1.287e-07
0.6616	7.990e+05	1.085e-01	2.337e-01	2.103e-04	4.530e-04
TOTALS:	8.637e+05	1.085e-01	2.338e-01	2.107e-04	4.536e-04

MicroShield v5.05 (5.05-00105)  
Stone & Webster

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Page : 1  
DOS File: S50CS.MS5  
Run Date: June 6, 2002  
Run Time: 8:53:37 AM  
Duration: 00:00:08

File Ref: \_\_\_\_\_  
Date: \_\_\_\_\_  
By: DR  
Checked: \_\_\_\_\_

Case Title: Soil AF 50 m<sup>2</sup>  
Description: Soil AF for Cs-137 only, 50 m<sup>2</sup>  
Geometry: 13 - Rectangular Volume



#### Source Dimensions

Length	15.0 cm	5.9 in
Width	707.1 cm	23 ft 2.4 in
Height	707.1 cm	23 ft 2.4 in

#### Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	115 cm	353.6 cm	353.6 cm
	3 ft 9.3 in	11 ft 7.2 in	11 ft 7.2 in

#### Shields

Shield Name	Dimension	Material	Density
Source	7.50e+06 cm <sup>3</sup>	soil (SiO <sub>2</sub> )	1.6
Air Gap		Air	0.00122

#### Source Input

##### Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	$\mu\text{Ci/cm}^3$	Bq/cm <sup>3</sup>
Ba-137m	1.2000e-005	4.4399e+005	1.6000e-006	5.9200e-002
Cs-137	1.2000e-005	4.4399e+005	1.6000e-006	5.9200e-002

#### Buildup

The material reference is : Source

#### Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

#### Results

Energy MeV	Activity photons/sec	Fluence Rate	Fluence Rate	Exposure Rate	Exposure Rate
		MeV/cm <sup>2</sup> /sec No Buildup	MeV/cm <sup>2</sup> /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.0318	9.192e+03	1.221e-05	1.775e-05	1.017e-07	1.478e-07
0.0322	1.696e+04	2.346e-05	3.438e-05	1.888e-07	2.767e-07
0.0364	6.171e+03	1.285e-05	2.080e-05	7.300e-08	1.182e-07
0.6616	3.995e+05	9.868e-02	2.088e-01	1.913e-04	4.047e-04
TOTALS:	4.318e+05	9.873e-02	2.088e-01	1.917e-04	4.053e-04

MicroShield v5.05 (5.05-00461)

Maine Yankee

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File Ref: \_\_\_\_\_

Date: \_\_\_\_\_

By: DR

Checked: \_\_\_\_\_

Page : 1

DOS File : S25CS.MS5

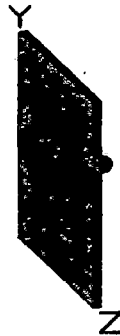
Run Date: May 17, 2002

Run Time: 8:24:07 AM

Duration : 00:00:07

Case Title: Soil AF 25 m<sup>2</sup>Description: Soil AF for Cs-137 only, 25 m<sup>2</sup>

Geometry: 13 - Rectangular Volume



## Source Dimensions

Length	15.0 cm	5.9 in
Width	500.0 cm	16 ft 4.9 in
Height	500.0 cm	16 ft 4.9 in

## Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	115 cm 3 ft 9.3 in	250 cm 8 ft 2.4 in	250 cm 8 ft 2.4 in

## Shields

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	3.75e+06 cm <sup>3</sup>	soil (SiO <sub>2</sub> )	1.6
Air Gap		Air	0.00122

## Source Input

## Grouping Method : Actual Photon Energies

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>μCi/cm<sup>3</sup></u>	<u>Bq/cm<sup>3</sup></u>
Ba-137m	6.0000e-006	2.2200e+005	1.6000e-006	5.9200e-002
Cs-137	6.0000e-006	2.2200e+005	1.6000e-006	5.9200e-002

## Buildup

The material reference is : Source

## Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

## Results

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.0318	4.596e+03	1.080e-05	1.563e-05	9.000e-08	1.302e-07
0.0322	8.480e+03	2.076e-05	3.028e-05	1.671e-07	2.437e-07
0.0364	3.086e+03	1.135e-05	1.831e-05	6.448e-08	1.041e-07
0.6616	1.998e+05	8.554e-02	1.762e-01	1.658e-04	3.415e-04

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JOS File : S25CS.MS5  
Run Date: May 17, 2002  
Run Time: 8:24:07 AM  
Duration : 00:00:07

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
TOTALS:	2.159e+05	8.558e-02	1.762e-01	1.661e-04	3.420e-04

MicroShield v5.05 (5.05-00461)  
Maine Yankee

Attachment 6-14

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File Ref:

Date:

By: DR

Checked:

Page : 1  
DOS File: S16CS.MS5  
Run Date: May 17, 2002  
Run Time: 8:27:32 AM  
Duration : 00:00:09

Case Title: Soil AF 16 m<sup>2</sup>  
Description: Soil AF for Cs-137 only, 16 m<sup>2</sup>  
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	15.0 cm	5.9 in
Width	400.0 cm	13 ft 1.5 in
Height	400.0 cm	13 ft 1.5 in

Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	115 cm 3 ft 9.3 in	200 cm 6 ft 6.7 in	200 cm 6 ft 6.7 in

Shields

Shield Name	Dimension	Material	Density
Source	2.40e+06 cm <sup>3</sup>	soil (SiO <sub>2</sub> )	1.6
Air Gap		Air	0.00122

Source Input

Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm <sup>2</sup>	Bq/cm <sup>2</sup>
Ba-137m	3.8400e-006	1.4208e+005	1.6000e-006	5.9200e-002
Cs-137	3.8400e-006	1.4208e+005	1.6000e-006	5.9200e-002

Buildup

The material reference is : Source

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm <sup>2</sup> /sec No Buildup	Fluence Rate MeV/cm <sup>2</sup> /sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	2.941e+03	9.678e-06	1.397e-05	8.061e-08	1.163e-07
0.0322	5.427e+03	1.859e-05	2.705e-05	1.496e-07	2.177e-07
0.0364	1.975e+03	1.015e-05	1.635e-05	5.770e-08	9.291e-08
0.6616	1.278e+05	7.531e-02	1.518e-01	1.460e-04	2.943e-04



JOS File : S16CS.MS5  
Run Date: May 17, 2002  
Run Time: 8:27:32 AM  
Duration : 00:00:09

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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
TOTALS:	1.382e+05	7.535e-02	1.519e-01	1.463e-04	2.947e-04

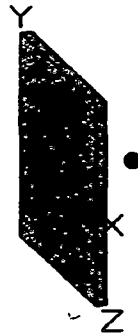
**MicroShield v5.05 (5.05-00461)**  
**Maine Yankee**

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Page : 1  
 JOS File : S10CS.MS5  
 Run Date: May 17, 2002  
 Run Time: 8:35:28 AM  
 Duration : 00:00:07

File Ref: \_\_\_\_\_  
 Date: \_\_\_\_\_  
 By: DR  
 Checked: \_\_\_\_\_

**Case Title: Soil AF 10 m<sup>2</sup>**  
**Description: Soil AF for Cs-137 only, 10 m<sup>2</sup>**  
**Geometry: 13 - Rectangular Volume**



**Source Dimensions**

Length	15.0 cm	5.9 in
Width	316.2 cm	10 ft 4.5 in
Height	316.2 cm	10 ft 4.5 in

**Dose Points**

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	115 cm 3 ft 9.3 in	158.1 cm 5 ft 2.2 in	158.1 cm 5 ft 2.2 in

**Shields**

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	1.50e+06 cm <sup>3</sup>	soil (SiO <sub>2</sub> )	1.6
Air Gap		Air	0.00122

**Source Input**

**Grouping Method : Actual Photon Energies**

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>μCi/cm<sup>3</sup></u>	<u>Bq/cm<sup>3</sup></u>
Ba-137m	2.3996e-006	8.8784e+004	1.6000e-006	5.9200e-002
Cs-137	2.3996e-006	8.8784e+004	1.6000e-006	5.9200e-002

**Buildup**

The material reference is : Source

**Integration Parameters**

X Direction	10
Y Direction	20
Z Direction	20

**Results**

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.0318	1.838e+03	8.329e-06	1.199e-05	6.938e-08	9.983e-08
0.0322	3.391e+03	1.600e-05	2.321e-05	1.288e-07	1.868e-07
0.0364	1.234e+03	8.730e-06	1.403e-05	4.960e-08	7.970e-08
0.6616	7.989e+04	6.344e-02	1.247e-01	1.230e-04	2.417e-04

JOS File : S10CS.MS5  
Run Date: May 17, 2002  
Run Time: 8:35:28 AM  
Duration : 00:00:07

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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
TOTALS:	8.635e+04	6.347e-02	1.247e-01	1.232e-04	2.421e-04

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Maine Yankee

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Page : 1

DOS File : S8CS.MS5

Run Date: May 17, 2002

Run Time: 8:37:33 AM

Duration : 00:00:09

File Ref: \_\_\_\_\_

Date: \_\_\_\_\_

By: DR

Checked: \_\_\_\_\_

Case Title: Soil AF 8 m<sup>2</sup>Description: Soil AF for Cs-137 only, 8 m<sup>2</sup>

Geometry: 13 - Rectangular Volume



## Source Dimensions

Length	15.0 cm	5.9 in
Width	282.8 cm	9 ft 3.3 in
Height	282.8 cm	9 ft 3.3 in

## Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	115 cm 3 ft 9.3 in	141.4 cm 4 ft 7.7 in	141.4 cm 4 ft 7.7 in

## Shields

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	1.20e+06 cm <sup>3</sup>	soil (SiO <sub>2</sub> )	1.6
Air Gap		Air	0.00122

## Source Input

## Grouping Method : Actual Photon Energies

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>μCi/cm<sup>3</sup></u>	<u>Bq/cm<sup>3</sup></u>
Ba-137m	1.9194e-006	7.1019e+004	1.6000e-006	5.9200e-002
Cs-137	1.9194e-006	7.1019e+004	1.6000e-006	5.9200e-002

## Buildup

The material reference is : Source

## Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

## Results

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.0318	1.470e+03	7.648e-06	1.099e-05	6.370e-08	9.153e-08
0.0322	2.713e+03	1.469e-05	2.128e-05	1.182e-07	1.713e-07
0.0364	9.872e+02	8.012e-06	1.286e-05	4.552e-08	7.307e-08
0.6616	6.390e+04	5.760e-02	1.118e-01	1.117e-04	2.168e-04

IOS File : S8CS.MS5  
Run Date: May 17, 2002  
Run Time: 8:37:33 AM  
Duration : 00:00:09

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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
TOTALS:	6.907e+04	5.763e-02	1.119e-01	1.119e-04	2.172e-04

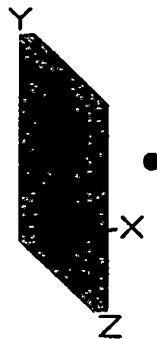
MicroShield v5.05 (5.05-00461)  
Maine Yankee

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Page : 1  
IOS File : S6CS.MS5  
Run Date: May 17, 2002  
Run Time: 8:44:26 AM  
Duration : 00:00:09

File Ref: \_\_\_\_\_  
Date: \_\_\_\_\_  
By: DR  
Checked: \_\_\_\_\_

Case Title: Soil AF 6 m<sup>2</sup>  
Description: Soil AF for Cs-137 only, 6 m<sup>2</sup>  
Geometry: 13 - Rectangular Volume



#### Source Dimensions

Length	15.0 cm	5.9 in
Width	244.9 cm	8 ft 0.4 in
Height	244.9 cm	8 ft 0.4 in

#### Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	115 cm 3 ft 9.3 in	122.5 cm 4 ft 0.2 in	122.5 cm 4 ft 0.2 in

#### Shields

Shield Name	Dimension	Material	Density
Source	9.00e+05 cm <sup>3</sup>	soil (SiO <sub>2</sub> )	1.6
Air Gap		Air	0.00122

#### Source Input

##### Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm <sup>3</sup>	Bq/cm <sup>3</sup>
Ba-137m	1.4394e-006	5.3259e+004	1.6000e-006	5.9200e-002
Cs-137	1.4394e-006	5.3259e+004	1.6000e-006	5.9200e-002

#### Buildup

The material reference is : Source

#### Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

#### Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm <sup>2</sup> /sec No Buildup	Fluence Rate MeV/cm <sup>2</sup> /sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	1.103e+03	6.751e-06	9.683e-06	5.623e-08	8.066e-08
0.0322	2.034e+03	1.297e-05	1.875e-05	1.044e-07	1.509e-07
0.0364	7.403e+02	7.068e-06	1.133e-05	4.016e-08	6.438e-08
0.6616	4.792e+04	5.008e-02	9.576e-02	9.708e-05	1.856e-04

IOS File : S6CS.MS5  
Run Date: May 17, 2002  
Run Time: 8:44:26 AM  
Duration : 00:00:09

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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
TOTALS:	5.180e+04	5.011e-02	9.580e-02	9.728e-05	1.859e-04

MicroShield v5.05 (5.05-00461)  
Maine Yankee

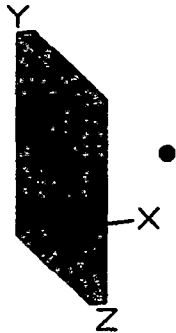
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Page : 1  
DOS File : S4CS.MS5  
Run Date: May 17, 2002  
Run Time: 8:46:52 AM  
Duration : 00:00:09

File Ref: \_\_\_\_\_  
Date: \_\_\_\_\_  
By: DR  
Checked: \_\_\_\_\_

Case Title: Soil AF 4 m<sup>2</sup>  
Description: Soil AF for Cs-137 only, 4 m<sup>2</sup>  
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	15.0 cm	5.9 in
Width	200.0 cm	6 ft 6.7 in
Height	200.0 cm	6 ft 6.7 in

Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	115 cm 3 ft 9.3 in	100 cm 3 ft 3.4 in	100 cm 3 ft 3.4 in

Shields

Shield Name	Dimension	Material	Density
Source	6.00e+05 cm <sup>3</sup>	soil (SiO <sub>2</sub> )	1.6
Air Gap		Air	0.00122

Source Input

Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	$\mu\text{Ci/cm}^3$	Bq/cm <sup>3</sup>
Ba-137m	9.6000e-007	3.5520e+004	1.6000e-006	5.9200e-002
Cs-137	9.6000e-007	3.5520e+004	1.6000e-006	5.9200e-002

Buildup

The material reference is : Source

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm <sup>2</sup> /sec <u>No Buildup</u>	Fluence Rate MeV/cm <sup>2</sup> /sec <u>With Buildup</u>	Exposure Rate mR/hr <u>No Buildup</u>	Exposure Rate mR/hr <u>With Buildup</u>
0.0318	7.354e+02	5.499e-06	7.872e-06	4.581e-08	6.557e-08
0.0322	1.357e+03	1.056e-05	1.525e-05	8.500e-08	1.227e-07
0.0364	4.937e+02	5.752e-06	9.208e-06	3.268e-08	5.232e-08
0.6616	3.196e+04	3.992e-02	7.480e-02	7.739e-05	1.450e-04



IOS File : S4CS.MS5  
Run Date: May 17, 2002  
Run Time: 8:46:52 AM  
Duration : 00:00:09

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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
TOTALS:	3.455e+04	3.994e-02	7.484e-02	7.755e-05	1.453e-04

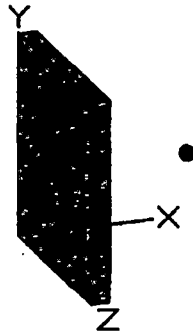
MICROShield V5.05 (5.05-00461)  
Maine Yankee

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Page : 1  
JOS File : S3CS.MS5  
Run Date: May 17, 2002  
Run Time: 8:53:12 AM  
Duration : 00:00:05

File Ref: \_\_\_\_\_  
Date: \_\_\_\_\_  
By: DR  
Checked: \_\_\_\_\_

Case Title: Soil AF 3 m<sup>2</sup>  
Description: Soil AF for Cs-137 only, 3 m<sup>2</sup>  
Geometry: 13 - Rectangular Volume



#### Source Dimensions

Length	15.0 cm	5.9 in
Width	173.2 cm	5 ft 8.2 in
Height	173.2 cm	5 ft 8.2 in

#### Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	115 cm 3 ft 9.3 in	86.6 cm 2 ft 10.1 in	86.6 cm 2 ft 10.1 in

#### Shields

Shield Name	Dimension	Material	Density
Source	4.50e+05 cm <sup>3</sup>	soil (SiO <sub>2</sub> )	1.6
Air Gap		Air	0.00122

#### Source Input

##### Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	$\mu\text{Ci/cm}^3$	Bq/cm <sup>3</sup>
Ba-137m	7.1996e-007	2.6638e+004	1.6000e-006	5.9200e-002
Cs-137	7.1996e-007	2.6638e+004	1.6000e-006	5.9200e-002

#### Buildup

The material reference is : Source

#### Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

#### Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm <sup>2</sup> /sec No Buildup	Fluence Rate MeV/cm <sup>2</sup> /sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	5.515e+02	4.653e-06	6.653e-06	3.876e-08	5.542e-08
0.0322	1.018e+03	8.936e-06	1.289e-05	7.192e-08	1.037e-07
0.0364	3.703e+02	4.863e-06	7.778e-06	2.763e-08	4.419e-08
0.6616	2.397e+04	3.327e-02	6.156e-02	6.450e-05	1.193e-04

JOS File : S3CS.MS5  
Run Date: May 17, 2002  
Run Time: 8:53:12 AM  
Duration : 00:00:05

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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
TOTALS:	2.591e+04	3.329e-02	6.158e-02	6.464e-05	1.195e-04

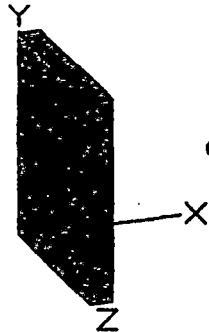
MICROShield v5.05 (5.05-00461)  
Maine Yankee

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Page : 1  
DOS File : S2CS.MS5  
Run Date: May 17, 2002  
Run Time: 8:55:48 AM  
Duration : 00:00:02

File Ref: \_\_\_\_\_  
Date: \_\_\_\_\_  
By: DR  
Checked: \_\_\_\_\_

Case Title: Soil AF 2 m<sup>2</sup>  
Description: Soil AF for Cs-137 only, 2 m<sup>2</sup>  
Geometry: 13 - Rectangular Volume



#### Source Dimensions

Length	15.0 cm	5.9 in
Width	141.4 cm	4 ft 7.7 in
Height	141.4 cm	4 ft 7.7 in

#### Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	115 cm 3 ft 9.3 in	70.71 cm 2 ft 3.8 in	70.71 cm 2 ft 3.8 in

#### Shields

Shield Name	Dimension	Material	Density
Source	3.00e+05 cm <sup>3</sup>	soil (SiO <sub>2</sub> )	1.6
Air Gap		Air	0.00122

#### Source Input

##### Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm <sup>3</sup>	Bq/cm <sup>3</sup>
Ba-137m	4.7986e-007	1.7755e+004	1.6000e-006	5.9200e-002
Cs-137	4.7986e-007	1.7755e+004	1.6000e-006	5.9200e-002

#### Buildup

The material reference is : Source

#### Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

#### Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm <sup>2</sup> /sec No Buildup	Fluence Rate MeV/cm <sup>2</sup> /sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	3.676e+02	3.569e-06	5.097e-06	2.973e-08	4.246e-08
0.0322	6.782e+02	6.854e-06	9.872e-06	5.516e-08	7.945e-08
0.0364	2.468e+02	3.727e-06	5.954e-06	2.118e-08	3.383e-08
0.6616	1.598e+04	2.503e-02	4.560e-02	4.853e-05	8.840e-05

JOS File : S2CS.MS5  
Run Date: May 17, 2002  
Run Time: 8:55:48 AM  
Duration : 00:00:02

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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
TOTALS:	1.727e+04	2.505e-02	4.562e-02	4.863e-05	8.856e-05

MICROShield v3.05 (3.05-00461)

Maine Yankee

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File Ref: \_\_\_\_\_

Date: \_\_\_\_\_

By: DA

Checked: \_\_\_\_\_

Page : 1

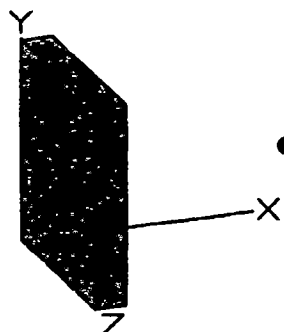
DOS File: S1CS.MS5

Run Date: May 17, 2002

Run Time: 9:16:15 AM

Duration : 00:00:07

Case Title: Soil AF 1 m<sup>2</sup>  
 Description: Soil AF for Cs-137 only, 1 m<sup>2</sup>  
 Geometry: 13 - Rectangular Volume

**Source Dimensions**

Length	15.0 cm	5.9 in
Width	100.0 cm	3 ft 3.4 in
Height	100.0 cm	3 ft 3.4 in

**Dose Points**

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	115 cm 3 ft 9.3 in	50 cm 1 ft 7.7 in	50 cm 1 ft 7.7 in

**Shields**

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	1.50e+05 cm <sup>3</sup>	soil (SiO <sub>2</sub> )	1.6
Air Gap		Air	0.00122

**Source Input****Grouping Method : Actual Photon Energies**

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>μCi/cm<sup>3</sup></u>	<u>Bq/cm<sup>3</sup></u>
Ba-137m	2.4000e-007	8.8800e+003	1.6000e-006	5.9200e-002
Cs-137	2.4000e-007	8.8800e+003	1.6000e-006	5.9200e-002

**Buildup**

The material reference is : Source

**Integration Parameters**

X Direction	10
Y Direction	20
Z Direction	20

**Results**

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.0318	1.838e+02	2.114e-06	3.014e-06	1.761e-08	2.511e-08
0.0322	3.392e+02	4.059e-06	5.837e-06	3.266e-08	4.698e-08
0.0364	1.234e+02	2.204e-06	3.515e-06	1.252e-08	1.997e-08
0.6616	7.990e+03	1.444e-02	2.580e-02	2.799e-05	5.001e-05

IOS File : STCS.MS5  
Run Date: May 17, 2002  
Run Time: 9:16:15 AM  
Duration : 00:00:07

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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
TOTALS:	8.637e+03	1.444e-02	2.581e-02	2.805e-05	5.010e-05

MICROShield v5.05 (5.05-00461)

Maine Yankee

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File Ref: \_\_\_\_\_

Date: \_\_\_\_\_

By: DR

Checked: \_\_\_\_\_

Page : 1

DOS File: S\_5CS.MS5

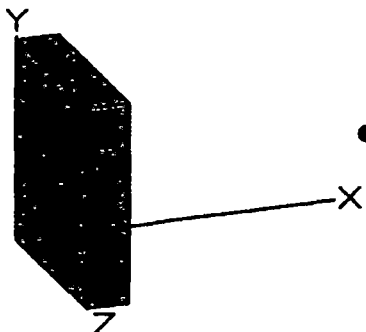
Run Date: May 17, 2002

Run Time: 9:05:35 AM

Duration : 00:00:02

Case Title: Soil AF 0.5 m<sup>2</sup>Description: Soil AF for Cs-137 only, 0.5 m<sup>2</sup>

Geometry: 13 - Rectangular Volume



## Source Dimensions

Length	15.0 cm	5.9 in
Width	70.71 cm	2 ft 3.8 in
Height	70.71 cm	2 ft 3.8 in

## Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	115 cm 3 ft 9.3 in	35.36 cm 1 ft 1.9 in	35.36 cm 1 ft 1.9 in

## Shields

Shield Name	Dimension	Material	Density
Source	7.50e+04 cm <sup>3</sup>	soil (SiO <sub>2</sub> )	1.6
Air Gap		Air	0.00122

## Source Input

## Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	$\mu\text{Ci/cm}^3$	Bq/cm <sup>3</sup>
Ba-137m	1.2000e-007	4.4399e+003	1.6000e-006	5.9200e-002
Cs-137	1.2000e-007	4.4399e+003	1.6000e-006	5.9200e-002

## Buildup

The material reference is : Source

## Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

## Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm <sup>2</sup> /sec No Buildup	Fluence Rate MeV/cm <sup>2</sup> /sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	9.192e+01	1.168e-06	1.664e-06	9.727e-09	1.386e-08
0.0322	1.696e+02	2.242e-06	3.222e-06	1.804e-08	2.593e-08
0.0364	6.171e+01	1.217e-06	1.938e-06	6.913e-09	1.101e-08
0.6616	3.995e+03	7.837e-03	1.384e-02	1.519e-05	2.683e-05



IOS File : S\_5CS.MS5  
Run Date: May 17, 2002  
Run Time: 9:05:35 AM  
Duration : 00:00:02

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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
TOTALS:	4.318e+03	7.842e-03	1.385e-02	1.523e-05	2.689e-05

microshield v9.03 (9.03-00401)

Maine Yankee

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File Ref: \_\_\_\_\_

Date: \_\_\_\_\_

By: DR

Checked: \_\_\_\_\_

Page : 1

IOS File: S\_25CS.MS5

Run Date: May 17, 2002

Run Time: 9:14:52 AM

Duration : 00:00:09

Case Title: Soil AF 0.25 m^2

Description: Soil AF for Cs-137 only, 0.25 m^2

Geometry: 13 - Rectangular Volume



## Source Dimensions

Length	15.0 cm	5.9 in
Width	50.0 cm	1 ft 7.7 in
Height	50.0 cm	1 ft 7.7 in

## Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	115 cm 3 ft 9.3 in	25 cm 9.8 in	25 cm 9.8 in

## Shields

Shield Name	Dimension	Material	Density
Source	3.75e+04 cm <sup>3</sup>	soil (SiO <sub>2</sub> )	1.6
Air Gap		Air	0.00122

## Source Input

## Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm <sup>3</sup>	Bq/cm <sup>3</sup>
Ba-137m	6.0000e-008	2.2200e+003	1.6000e-006	5.9200e-002
Cs-137	6.0000e-008	2.2200e+003	1.6000e-006	5.9200e-002

## Buildup

The material reference is : Source

## Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

## Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm <sup>2</sup> /sec No Buildup	Fluence Rate MeV/cm <sup>2</sup> /sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	4.596e+01	6.169e-07	8.784e-07	5.138e-09	7.317e-09
0.0322	8.480e+01	1.184e-06	1.701e-06	9.532e-09	1.369e-08
0.0364	3.086e+01	6.424e-07	1.023e-06	3.650e-09	5.809e-09
0.6616	1.998e+03	4.098e-03	7.191e-03	7.945e-06	1.394e-05

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JOS File : S\_2505.MSS

Run Date: May 17, 2002

Run Time: 9:14:52 AM

Duration : 00:00:09

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
TOTALS:	2.159e+03	4.100e-03	7.195e-03	7.963e-06	1.397e-05

**MYAPC License Termination Plan**  
**Revision 3**  
**October 15, 2002**

**Attachment 6-15**  
**Standing Building Area Factor Microshield Output**

Attachment 6-15 illustrates the Microshield runs for determination of standing building area factors. The associated Engineering Calculation for standing building area factors provides all the Microshield runs used to derive the area factors for the Maine Yankee nuclide mixture and mixtures containing 100 percent Co-60 and 100 percent Cs-137. These are presented in Section 6, Table 6-14 of the LTP. The runs illustrated in this attachment are for the Maine Yankee nuclide mixture.

MicroShield v5.05 (5.05-00105)  
Stone & Webster

C91C 016-01 (MY)  
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File Ref: \_\_\_\_\_  
Date: \_\_\_\_\_  
By: DR  
Checked: \_\_\_\_\_

Page : 1  
DOS File: CC10000.MS5  
Run Date: June 12, 2002  
Run Time: 7:48:19 AM  
Duration: 00:00:06

Case Title: AF 10,000 m<sup>2</sup>  
Description: Contaminated Concrete - MY nuclide mix  
Geometry: 4 - Rectangular Area - Vertical



Source Dimensions  
Width 1.0e+4 cm 328 ft 1.0 in  
Height 1.0e+4 cm 328 ft 1.0 in

Dose Points  
# 1 X 100 cm Y 5000 cm Z 5000 cm  
3 ft 3.4 in 164 ft 0.5 in 164 ft 0.5 in

Shields  
Shield Name Material Density  
Air Gap Air 0.00122

Source Input  
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^2$	Bq/cm <sup>2</sup>
Ba-137m	2.4800e-007	9.1760e+003	2.4800e-009	9.1760e-005
Co-57	1.3800e-010	5.1060e+000	1.3800e-012	5.1060e-008
Co-60	2.6300e-008	9.7310e+002	2.6300e-010	9.7310e-006
Cs-134	2.0500e-009	7.5850e+001	2.0500e-011	7.5850e-007
Cs-137	2.4800e-007	9.1760e+003	2.4800e-009	9.1760e-005
Fe-55	2.1700e-009	8.0290e+001	2.1700e-011	8.0290e-007
H-3	1.0600e-008	3.9220e+002	1.0600e-010	3.9220e-006
Ni-63	1.6000e-007	5.9200e+003	1.6000e-009	5.9200e-005
Sr-90	1.2600e-009	4.6620e+001	1.2600e-011	4.6620e-007
Y-90	1.2600e-009	4.6620e+001	1.2600e-011	4.6620e-007

Buildup  
The material reference is : Air Gap

Integration Parameters  
Z Direction 20  
Y Direction 20

Energy MeV	Activity photons/sec	Fluence Rate		Exposure Rate	
		$\text{MeV}/\text{cm}^2/\text{sec}$ No Buildup	$\text{MeV}/\text{cm}^2/\text{sec}$ With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.0318	1.900e+02	8.502e-08	1.222e-07	7.082e-10	1.018e-09
0.0318	1.626e-01	7.277e-11	1.046e-10	6.062e-13	8.712e-13
0.0322	3.505e+02	1.595e-07	2.302e-07	1.283e-09	1.853e-09
0.0322	3.000e-01	1.365e-10	1.971e-10	1.099e-12	1.586e-12
0.0364	1.275e+02	6.839e-08	1.031e-07	3.886e-10	5.857e-10
0.0364	1.092e-01	5.854e-11	8.824e-11	3.326e-13	5.013e-13
0.1221	4.366e+00	8.929e-09	1.264e-08	1.400e-11	1.982e-11

Page : 2  
DOS File: CC10000.MS5  
Run Date: June 12, 2002  
Run Time: 7:48:19 AM  
Duration: 00:00:06

CALC 916-01 (MAY)  
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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.1365	5.414e-01	1.245e-09	1.728e-09	2.002e-12	2.779e-12
0.2769	2.685e-02	1.300e-10	1.567e-10	2.439e-13	2.939e-13
0.4753	1.107e+00	9.470e-09	1.076e-08	1.858e-11	2.110e-11
0.536	1.464e-03	1.420e-11	1.596e-11	2.785e-14	3.130e-14
0.5632	6.356e+00	6.496e-08	7.272e-08	1.272e-10	1.424e-10
0.5693	1.170e+01	1.210e-07	1.353e-07	2.368e-10	2.648e-10
0.6047	7.403e+01	8.152e-07	9.073e-07	1.590e-09	1.770e-09
0.6616	8.257e+03	9.992e-05	1.104e-04	1.937e-07	2.141e-07
0.692	8.164e-03	1.036e-10	1.141e-10	2.000e-13	2.203e-13
0.6938	1.587e-01	2.019e-09	2.224e-09	3.898e-12	4.293e-12
0.7958	6.478e+01	9.513e-07	1.038e-06	1.811e-09	1.975e-09
0.8019	6.622e+00	9.802e-08	1.069e-07	1.864e-10	2.033e-10
1.0386	7.585e-01	1.472e-08	1.582e-08	2.695e-11	2.898e-11
1.1679	1.365e+00	2.994e-08	3.202e-08	5.356e-11	5.727e-11
1.1732	9.731e+02	2.144e-05	2.292e-05	3.832e-08	4.096e-08
1.3325	9.731e+02	2.449e-05	2.603e-05	4.248e-08	4.515e-08
1.3652	2.306e+00	5.951e-08	6.318e-08	1.026e-10	1.089e-10
TOTALS:	1.105e+04	1.483e-04	1.622e-04	2.811e-07	3.083e-07

MicroShield v5.05 (5.05-00105)  
Stone & Webster

(910 016-02 (MY)

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File Ref:

Date:

By:

Checked:

Page : 1  
DOS File: CC5000.MS5  
Run Date: June 12, 2002  
Run Time: 8:34:10 AM  
Duration: 00:00:06

Case Title: AF 5,000 m<sup>2</sup>  
Description: Contaminated Concrete - MY nuclide mix  
Geometry: 4 - Rectangular Area - Vertical



## Source Dimensions

Width 7.1e+3 cm 231 ft 11.9 in  
Height 7.1e+3 cm 231 ft 11.9 in

## Dose Points

	X	Y	Z
# 1	100 cm	3536 cm	3536 cm
	3 ft 3.4 in	16 ft 0.1 in	16 ft 0.1 in

## Shields

Shield Name	Material	Density
Air Gap	Air	0.00122

## Source Input

## Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^2$	Bq/cm <sup>2</sup>
Ba-137m	1.2400e-007	4.5879e+003	2.4800e-009	9.1760e-005
Co-57	6.8999e-011	2.5530e+000	1.3800e-012	5.1060e-008
Co-60	1.3150e-008	4.8654e+002	2.6300e-010	9.7310e-006
Cs-134	1.0250e-009	3.7924e+001	2.0500e-011	7.5850e-007
Cs-137	1.2400e-007	4.5879e+003	2.4800e-009	9.1760e-005
Fe-55	1.0850e-009	4.0144e+001	2.1700e-011	8.0290e-007
H-3	5.2999e-009	1.9610e+002	1.0600e-010	3.9220e-006
Ni-63	7.9998e-008	2.9599e+003	1.6000e-009	5.9200e-005
Sr-90	6.2999e-010	2.3310e+001	1.2600e-011	4.6620e-007
Y-90	6.2999e-010	2.3310e+001	1.2600e-011	4.6620e-007

## Buildup

The material reference is : Air Gap

## Integration Parameters

Z Direction 20  
Y Direction 20

## Results

Energy MeV	Activity photons/sec	Fluence Rate		Exposure Rate	
		No Buildup MeV/cm <sup>2</sup> /sec	With Buildup MeV/cm <sup>2</sup> /sec	No Buildup mR/hr	With Buildup mR/hr
0.0318	9.498e+01	8.134e-08	1.141e-07	6.775e-10	9.503e-10
0.0318	8.130e-02	6.962e-11	9.765e-11	5.799e-13	8.134e-13
0.0322	1.752e+02	1.525e-07	2.146e-07	1.227e-09	1.727e-09
0.0322	1.500e-01	1.305e-10	1.837e-10	1.050e-12	1.478e-12
0.0364	6.377e+01	6.513e-08	9.446e-08	3.701e-10	5.367e-10
0.0364	5.459e-02	5.575e-11	8.086e-11	3.168e-13	4.594e-13
0.1221	2.183e+00	8.364e-09	1.111e-08	1.311e-11	1.742e-11



Page : 2  
 DOS File: CC5000.MS5  
 Run Date: June 12, 2002  
 Run Time: 8:34:10 AM  
 Duration: 00:00:06

CALC 016 -03 CMY,  
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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.1365	2.707e-01	1.165e-09	1.524e-09	1.874e-12	2.450e-12
0.2769	1.343e-02	1.210e-10	1.406e-10	2.269e-13	2.637e-13
0.4753	5.537e-01	8.767e-09	9.709e-09	1.720e-11	1.905e-11
0.536	7.318e-04	1.313e-11	1.442e-11	2.575e-14	2.828e-14
0.5632	3.178e+00	6.005e-08	6.572e-08	1.176e-10	1.287e-10
0.5693	5.852e+00	1.118e-07	1.223e-07	2.188e-10	2.393e-10
0.6047	3.701e+01	7.530e-07	8.204e-07	1.469e-09	1.601e-09
0.6616	4.128e+03	9.222e-05	9.991e-05	1.788e-07	1.937e-07
0.692	4.082e-03	9.555e-11	1.032e-10	1.845e-13	1.994e-13
0.6938	7.936e-02	1.863e-09	2.012e-09	3.596e-12	3.885e-12
0.7958	3.239e+01	8.766e-07	9.397e-07	1.668e-09	1.789e-09
0.8019	3.311e+00	9.032e-08	9.679e-08	1.717e-10	1.841e-10
1.0386	3.792e-01	1.353e-08	1.434e-08	2.477e-11	2.625e-11
1.1679	6.826e-01	2.750e-08	2.901e-08	4.919e-11	5.189e-11
1.1732	4.865e+02	1.969e-05	2.077e-05	3.519e-08	3.711e-08
1.3325	4.865e+02	2.247e-05	2.358e-05	3.898e-08	4.091e-08
1.3652	1.153e+00	5.458e-08	5.725e-08	9.413e-11	9.872e-11
TOTALS:	5.523e+03	1.367e-04	1.469e-04	2.591e-07	2.791e-07

MicroShield v5.05 (5.05-00105)  
Stone & Webster

CNIC 016-011 (MY)

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File Ref: \_\_\_\_\_

Date: \_\_\_\_\_

By: DR

Checked: \_\_\_\_\_

Page : 1  
DOS File: CC2500.MS5  
Run Date: June 12, 2002  
Run Time: 8:35:46 AM  
Duration: 00:00:05

Case Title: AF 2,500 m<sup>2</sup>  
Description: Contaminated Concrete - MY nuclide mix  
Geometry: 4 - Rectangular Area - Vertical



#### Source Dimensions

Width 5.0e+3 cm 164 ft 0.5 in  
Height 5.0e+3 cm 164 ft 0.5 in

#### Dose Points

#	X	Y	Z
1	100 cm	2500 cm	2500 cm
	3 ft 3.4 in	82 ft 0.3 in	82 ft 0.3 in

#### Shields

Shield Name	Material	Density
Air Gap	Air	0.00122

#### Source Input

##### Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^2$	Bq/cm <sup>2</sup>
Ba-137m	6.2000e-008	2.2940e+003	2.4800e-009	9.1760e-005
Co-57	3.4500e-011	1.2765e+000	1.3800e-012	5.1060e-008
Co-60	6.5750e-009	2.4328e+002	2.6300e-010	9.7310e-006
Cs-134	5.1250e-010	1.8963e+001	2.0500e-011	7.5850e-007
Cs-137	6.2000e-008	2.2940e+003	2.4800e-009	9.1760e-005
Fe-55	5.4250e-010	2.0073e+001	2.1700e-011	8.0290e-007
H-3	2.6500e-009	9.8050e+001	1.0600e-010	3.9220e-006
Ni-63	4.0000e-008	1.4800e+003	1.6000e-009	5.9200e-005
Sr-90	3.1500e-010	1.1655e+001	1.2600e-011	4.6620e-007
Y-90	3.1500e-010	1.1655e+001	1.2600e-011	4.6620e-007

#### Buildup

The material reference is : Air Gap

#### Integration Parameters

Z Direction 20  
Y Direction 20

#### Results

Energy MeV	Activity photons/sec	Fluence Rate		Exposure Rate	
		No Buildup	With Buildup	No Buildup	With Buildup
0.0318	4.749e+01	7.729e-08	1.046e-07	6.438e-10	8.712e-10
0.0318	4.065e-02	6.616e-11	8.952e-11	5.511e-13	7.457e-13
0.0322	8.762e+01	1.448e-07	1.964e-07	1.166e-09	1.581e-09
0.0322	7.500e-02	1.240e-10	1.681e-10	9.977e-13	1.353e-12
0.0364	3.189e+01	6.155e-08	8.501e-08	3.497e-10	4.830e-10
0.0364	2.729e-02	5.269e-11	7.277e-11	2.994e-13	4.134e-13
0.1221	1.092e+00	7.766e-09	9.738e-09	1.218e-11	1.527e-11

Page : 2  
 DOS File: CC2500.MS5  
 Run Date: June 12, 2002  
 Run Time: 8:35:46 AM  
 Duration: 00:00:05

CALC 016-01 (MAY)  
 Rev 2, Att 2  
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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.1365	1.353e-01	1.081e-09	1.338e-09	1.738e-12	2.152e-12
0.2769	6.713e-03	1.116e-10	1.257e-10	2.093e-13	2.359e-13
0.4753	2.769e-01	8.052e-09	8.732e-09	1.580e-11	1.713e-11
0.536	3.659e-04	1.205e-11	1.298e-11	2.363e-14	2.545e-14
0.5632	1.589e+00	5.508e-08	5.917e-08	1.078e-10	1.158e-10
0.5693	2.926e+00	1.025e-07	1.101e-07	2.007e-10	2.155e-10
0.6047	1.851e+01	6.903e-07	7.389e-07	1.347e-09	1.442e-09
0.6616	2.064e+03	8.448e-05	9.002e-05	1.638e-07	1.745e-07
0.692	2.041e-03	8.750e-11	9.303e-11	1.690e-13	1.797e-13
0.6938	3.968e-02	1.706e-09	1.813e-09	3.293e-12	3.501e-12
0.7958	1.619e+01	8.019e-07	8.473e-07	1.526e-09	1.613e-09
0.8019	1.655e+00	8.262e-08	8.727e-08	1.571e-10	1.660e-10
1.0386	1.896e-01	1.235e-08	1.293e-08	2.262e-11	2.368e-11
1.1679	3.413e-01	2.509e-08	2.617e-08	4.487e-11	4.681e-11
1.1732	2.433e+02	1.796e-05	1.873e-05	3.210e-08	3.348e-08
1.3325	2.433e+02	2.047e-05	2.127e-05	3.552e-08	3.691e-08
1.3652	5.765e-01	4.974e-08	5.164e-08	8.577e-11	8.906e-11
TOTALS:	2.761e+03	1.250e-04	1.324e-04	2.371e-07	2.516e-07

MicroShield v5.05 (5.05-00105)  
Stone & Webster

CGIC 016-01 (MY)

Rev 2, Att 2

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Page : 1  
DOS File: CC2000.MS5  
Run Date: June 12, 2002  
Run Time: 8:37:23 AM  
Duration: 00:00:05

File Ref: \_\_\_\_\_

Date: \_\_\_\_\_

By: DR

Checked: \_\_\_\_\_

Case Title: AF 2,000 m<sup>2</sup>  
Description: Contaminated Concrete - MY nuclide mix  
Geometry: 4 - Rectangular Area - Vertical



#### Source Dimensions

Width 4.5e+3 cm 146 ft 8.6 in  
Height 4.5e+3 cm 146 ft 8.6 in

#### Dose Points

#	X	Y	Z
1	100 cm	2236 cm	2236 cm
	3 ft 3.4 in	73 ft 4.3 in	73 ft 4.3 in

#### Shields

Shield Name	Material	Density
Air Gap	Air	0.00122

#### Source Input

##### Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^2$	Bq/cm <sup>2</sup>
Ba-137m	4.9597e-008	1.8351e+003	2.4800e-009	9.1760e-005
Co-57	2.7598e-011	1.0211e+000	1.3800e-012	5.1060e-008
Co-60	5.2597e-009	1.9461e+002	2.6300e-010	9.7310e-006
Cs-134	4.0998e-010	1.5169e+001	2.0500e-011	7.5850e-007
Cs-137	4.9597e-008	1.8351e+003	2.4800e-009	9.1760e-005
Fe-55	4.3397e-010	1.6057e+001	2.1700e-011	8.0290e-007
H-3	2.1199e-009	7.8435e+001	1.0600e-010	3.9220e-006
Ni-63	3.1998e-008	1.1839e+003	1.6000e-009	5.9200e-005
Sr-90	2.5198e-010	9.3234e+000	1.2600e-011	4.6620e-007
Y-90	2.5198e-010	9.3234e+000	1.2600e-011	4.6620e-007

#### Buildup

The material reference is : Air Gap

#### Integration Parameters

Z Direction 20  
Y Direction 20

#### Results

Energy MeV	Activity photons/sec	Fluence Rate		Exposure Rate	
		No Buildup	With Buildup	No Buildup	With Buildup
0.0318	3.799e+01	7.591e-08	1.014e-07	6.323e-10	8.443e-10
0.0318	3.252e-02	6.498e-11	8.676e-11	5.412e-13	7.227e-13
0.0322	7.009e+01	1.422e-07	1.902e-07	1.145e-09	1.531e-09
0.0322	6.000e-02	1.217e-10	1.628e-10	9.797e-13	1.310e-12
0.0364	2.551e+01	6.034e-08	8.194e-08	3.428e-10	4.655e-10
0.0364	2.183e-02	5.165e-11	7.014e-11	2.934e-13	3.985e-13
0.1221	8.732e-01	7.570e-09	9.333e-09	1.187e-11	1.463e-11

Page : 2  
 DOS File: CC2000.MS5  
 Run Date: June 12, 2002  
 Run Time: 8:37:23 AM  
 Duration: 00:00:05

Call 016-071 (M/R)

Rev 2, Att 2

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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.1365	1.083e-01	1.053e-09	1.283e-09	1.694e-12	2.064e-12
0.2769	5.370e-03	1.086e-10	1.213e-10	2.036e-13	2.275e-13
0.4753	2.215e-01	7.824e-09	8.434e-09	1.535e-11	1.655e-11
0.536	2.927e-04	1.170e-11	1.254e-11	2.295e-14	2.459e-14
0.5632	1.271e+00	5.349e-08	5.717e-08	1.047e-10	1.119e-10
0.5693	2.341e+00	9.959e-08	1.064e-07	1.949e-10	2.082e-10
0.6047	1.481e+01	6.703e-07	7.139e-07	1.308e-09	1.393e-09
0.6616	1.651e+03	8.202e-05	8.700e-05	1.590e-07	1.687e-07
0.692	1.633e-03	8.494e-11	8.991e-11	1.640e-13	1.736e-13
0.6938	3.174e-02	1.656e-09	1.753e-09	3.197e-12	3.384e-12
0.7958	1.295e+01	7.782e-07	8.190e-07	1.481e-09	1.559e-09
0.8019	1.324e+00	8.018e-08	8.436e-08	1.525e-10	1.604e-10
1.0386	1.517e-01	1.198e-08	1.250e-08	2.194e-11	2.289e-11
1.1679	2.730e-01	2.433e-08	2.529e-08	4.351e-11	4.525e-11
1.1732	1.946e+02	1.742e-05	1.811e-05	3.113e-08	3.236e-08
1.3325	1.946e+02	1.985e-05	2.056e-05	3.443e-08	3.568e-08
1.3652	4.611e-01	4.821e-08	4.992e-08	8.314e-11	8.609e-11
TOTALS:	2.209e+03	1.214e-04	1.279e-04	2.301e-07	2.432e-07

MicroShield v5.05 (5.05-00105)  
Stone & Webster

CC1000 016-01 (MY)  
RevZ, AttZ  
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File Ref: \_\_\_\_\_  
Date: \_\_\_\_\_  
By: DR  
Checked: \_\_\_\_\_

Page : 1  
DOS File: CC1000.MS5  
Run Date: June 12, 2002  
Run Time: 10:25:27 AM  
Duration: 00:00:05

Case Title: AF 1,000 m<sup>2</sup>  
Description: Contaminated Concrete - MY nuclide mix  
Geometry: 4 - Rectangular Area - Vertical



Source Dimensions  
Width 3.2e+3 cm 103 ft 8.9 in  
Height 3.2e+3 cm 103 ft 8.9 in

Dose Points  
# 1 X 100 cm Y 1581 cm Z 1581 cm  
3 ft 3.4 in 51 ft 10.4 in 51 ft 10.4 in

Shields  

Shield Name	Material	Density
Air Gap	Air	0.00122

Source Input  
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^2$	Bq/cm <sup>2</sup>
Ba-137m	2.4796e-008	9.1744e+002	2.4800e-009	9.1760e-005
Co-57	1.3798e-011	5.1051e-001	1.3800e-012	5.1060e-008
Co-60	2.6295e-009	9.7293e+001	2.6300e-010	9.7310e-006
Cs-134	2.0496e-010	7.5837e+000	2.0500e-011	7.5850e-007
Cs-137	2.4796e-008	9.1744e+002	2.4800e-009	9.1760e-005
Fe-55	2.1696e-010	8.0276e+000	2.1700e-011	8.0290e-007
H-3	1.0598e-009	3.9213e+001	1.0600e-010	3.9220e-006
Ni-63	1.5997e-008	5.9190e+002	1.6000e-009	5.9200e-005
Sr-90	1.2598e-010	4.6612e+000	1.2600e-011	4.6620e-007
Y-90	1.2598e-010	4.6612e+000	1.2600e-011	4.6620e-007

Buildup  
The material reference is : Air Gap

Integration Parameters  
Z Direction 20  
Y Direction 20

Energy MeV	Activity photons/sec	Results			
		Fluence Rate MeV/cm <sup>2</sup> /sec No Buildup	Fluence Rate MeV/cm <sup>2</sup> /sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	1.899e+01	7.105e-08	9.075e-08	5.918e-10	7.559e-10
0.0318	1.626e-02	6.082e-11	7.768e-11	5.066e-13	6.470e-13
0.0322	3.504e+01	1.330e-07	1.701e-07	1.071e-09	1.369e-09
0.0322	3.000e-02	1.139e-10	1.456e-10	9.164e-13	1.172e-12
0.0364	1.275e+01	5.615e-08	7.224e-08	3.190e-10	4.104e-10
0.0364	1.092e-02	4.806e-11	6.183e-11	2.731e-13	3.513e-13
0.1221	4.365e-01	6.931e-09	8.168e-09	1.087e-11	1.281e-11

Page : 2  
 DOS File: CC1000.MS5  
 Run Date: June 12, 2002  
 Run Time: 10:25:27 AM  
 Duration: 00:00:05

C91C 016-21 (M7)

Rev 2, Att 2

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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.1365	5.413e-02	9.639e-10	1.125e-09	1.550e-12	1.809e-12
0.2769	2.685e-03	9.887e-11	1.079e-10	1.855e-13	2.024e-13
0.4753	1.107e-01	7.100e-09	7.533e-09	1.393e-11	1.478e-11
0.536	1.463e-04	1.061e-11	1.120e-11	2.081e-14	2.197e-14
0.5632	6.355e-01	4.849e-08	5.109e-08	9.494e-11	1.000e-10
0.5693	1.170e+00	9.027e-08	9.508e-08	1.767e-10	1.861e-10
0.6047	7.402e+00	6.074e-07	6.383e-07	1.185e-09	1.245e-09
0.6616	8.255e+02	7.428e-05	7.780e-05	1.440e-07	1.508e-07
0.692	8.163e-04	7.690e-11	8.042e-11	1.485e-13	1.553e-13
0.6938	1.587e-02	1.499e-09	1.568e-09	2.894e-12	3.027e-12
0.7958	6.476e+00	7.039e-07	7.328e-07	1.340e-09	1.395e-09
0.8019	6.621e-01	7.252e-08	7.548e-08	1.379e-10	1.435e-10
1.0386	7.584e-02	1.082e-08	1.119e-08	1.981e-11	2.049e-11
1.1679	1.365e-01	2.196e-08	2.264e-08	3.927e-11	4.050e-11
1.1732	9.729e+01	1.572e-05	1.621e-05	2.809e-08	2.897e-08
1.3325	9.729e+01	1.790e-05	1.841e-05	3.106e-08	3.194e-08
1.3652	2.305e-01	4.348e-08	4.469e-08	7.498e-11	7.706e-11
TOTALS:	1.104e+03	1.098e-04	1.144e-04	2.082e-07	2.175e-07

MicroShield v5.05 (5.05-00105)  
Stone & Webster

Case 016-02 (MY)

Rev 2, Att 2

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File Ref: \_\_\_\_\_

Date: \_\_\_\_\_

By: DR

Checked: \_\_\_\_\_

Page : 1  
DOS File: CC500.MS5  
Run Date: June 12, 2002  
Run Time: 10:26:42 AM  
Duration: 00:00:05

Case Title: AF 500 m<sup>2</sup>  
Description: Contaminated Concrete - MY nuclide mix  
Geometry: 4 - Rectangular Area - Vertical



#### Source Dimensions

Width 2.2e+3 cm 73 ft 4.3 in  
Height 2.2e+3 cm 73 ft 4.3 in

#### Dose Points

#	X	Y	Z
1	100 cm	1118 cm	1118 cm
	3 ft 3.4 in	36 ft 8.2 in	36 ft 8.2 in

#### Shields

Shield Name	Material	Density
Air Gap	Air	0.00122

#### Source Input

##### Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^2$	Bq/cm <sup>2</sup>
Ba-137m	1.2399e-008	4.5877e+002	2.4800e-009	9.1760e-005
Co-57	6.8996e-012	2.5528e-001	1.3800e-012	5.1060e-008
Co-60	1.3149e-009	4.8652e+001	2.6300e-010	9.7310e-006
Cs-134	1.0249e-010	3.7923e+000	2.0500e-011	7.5850e-007
Cs-137	1.2399e-008	4.5877e+002	2.4800e-009	9.1760e-005
Fe-55	1.0849e-010	4.0143e+000	2.1700e-011	8.0290e-007
H-3	5.2997e-010	1.9609e+001	1.0600e-010	3.9220e-006
Ni-63	7.9995e-009	2.9598e+002	1.6000e-009	5.9200e-005
Sr-90	6.2996e-011	2.3309e+000	1.2600e-011	4.6620e-007
Y-90	6.2996e-011	2.3309e+000	1.2600e-011	4.6620e-007

#### Buildup

The material reference is : Air Gap

#### Integration Parameters

Z Direction 20  
Y Direction 20

#### Results

Energy MeV	Activity photons/sec	Fluence Rate		Exposure Rate	
		No Buildup	With Buildup	No Buildup	With Buildup
0.0318	9.498e+00	6.506e-08	7.939e-08	5.420e-10	6.613e-10
0.0318	8.130e-03	5.569e-11	6.796e-11	4.639e-13	5.661e-13
0.0322	1.752e+01	1.218e-07	1.486e-07	9.799e-10	1.196e-09
0.0322	1.500e-02	1.042e-10	1.272e-10	8.388e-13	1.024e-12
0.0364	6.377e+00	5.116e-08	6.253e-08	2.907e-10	3.553e-10
0.0364	5.459e-03	4.379e-11	5.353e-11	2.488e-13	3.041e-13
0.1221	2.183e-01	6.228e-09	7.088e-09	9.765e-12	1.111e-11



Page : 2  
 DOS File: CC500.MS5  
 Run Date: June 12, 2002  
 Run Time: 10:26:42 AM  
 Duration: 00:00:05

CALC 016-011 01/11/01

Rev2, Att 2

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Energy MeV	Activity photons/sec	Fluence Rate	Fluence Rate	Exposure Rate	Exposure Rate
		<u>MeV/cm<sup>2</sup>/sec</u>	<u>MeV/cm<sup>2</sup>/sec</u>	<u>mR/hr</u>	<u>mR/hr</u>
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.1365	2.707e-02	8.656e-10	9.780e-10	1.392e-12	1.573e-12
0.2769	1.342e-03	8.845e-11	9.477e-11	1.659e-13	1.778e-13
0.4753	5.537e-02	6.333e-09	6.637e-09	1.243e-11	1.302e-11
0.536	7.317e-05	9.461e-12	9.876e-12	1.855e-14	1.937e-14
0.5632	3.178e-01	4.322e-08	4.504e-08	8.462e-11	8.819e-11
0.5693	5.851e-01	8.045e-08	8.383e-08	1.575e-10	1.641e-10
0.6047	3.701e+00	5.411e-07	5.628e-07	1.056e-09	1.098e-09
0.6616	4.128e+02	6.615e-05	6.862e-05	1.282e-07	1.330e-07
0.692	4.082e-04	6.847e-11	7.094e-11	1.322e-13	1.370e-13
0.6938	7.936e-03	1.335e-09	1.383e-09	2.577e-12	2.670e-12
0.7958	3.239e+00	6.264e-07	6.466e-07	1.192e-09	1.231e-09
0.8019	3.311e-01	6.453e-08	6.660e-08	1.227e-10	1.266e-10
1.0386	3.792e-02	9.617e-09	9.873e-09	1.761e-11	1.808e-11
1.1679	6.826e-02	1.950e-08	1.998e-08	3.489e-11	3.574e-11
1.1732	4.865e+01	1.396e-05	1.431e-05	2.495e-08	2.557e-08
1.3325	4.865e+01	1.589e-05	1.625e-05	2.757e-08	2.819e-08
1.3652	1.153e-01	3.860e-08	3.944e-08	6.656e-11	6.801e-11
TOTALS:	5.522e+02	9.769e-05	1.010e-04	1.853e-07	1.919e-07

MicroShield v5.05 (5.05-00105)  
Stone & Webster

Calc 016-01 (M1)  
Rev 2, Att 2  
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Page : 1  
DOS File: CC300.MS5  
Run Date: June 12, 2002  
Run Time: 10:27:56 AM  
Duration: 00:00:05

File Ref: \_\_\_\_\_  
Date: \_\_\_\_\_  
By: DR  
Checked: \_\_\_\_\_

Case Title: AF 300 m<sup>2</sup>  
Description: Contaminated Concrete - MY nuclide mix  
Geometry: 4 - Rectangular Area - Vertical



Source Dimensions  
Width 1.7e+3 cm 56 ft 9.9 in  
Height 1.7e+3 cm 56 ft 9.9 in

Dose Points  
# 1 X 100 cm Y 866 cm Z 866 cm  
3 ft 3.4 in 28 ft 4.9 in 28 ft 4.9 in

Shields  

Shield Name	Material	Density
Air Gap	Air	0.00122

Source Input  
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^2$	Bq/cm <sup>2</sup>
Ba-137m	7.4396e-009	2.7526e+002	2.4800e-009	9.1760e-005
Co-57	4.1398e-012	1.5317e-001	1.3800e-012	5.1060e-008
Co-60	7.8895e-010	2.9191e+001	2.6300e-010	9.7310e-006
Cs-134	6.1496e-011	2.2754e+000	2.0500e-011	7.5850e-007
Cs-137	7.4396e-009	2.7526e+002	2.4800e-009	9.1760e-005
Fe-55	6.5096e-011	2.4086e+000	2.1700e-011	8.0290e-007
H-3	3.1798e-010	1.1765e+001	1.0600e-010	3.9220e-006
Ni-63	4.7997e-009	1.7759e+002	1.6000e-009	5.9200e-005
Sr-90	3.7798e-011	1.3985e+000	1.2600e-011	4.6620e-007
Y-90	3.7798e-011	1.3985e+000	1.2600e-011	4.6620e-007

Buildup  
The material reference is : Air Gap

Integration Parameters  
Z Direction 20  
Y Direction 20

Results

Energy MeV	Activity photons/sec	Fluence Rate		Exposure Rate	
		MeV/cm <sup>2</sup> /sec No Buildup	MeV/cm <sup>2</sup> /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.0318	5.699e+00	5.996e-08	7.101e-08	4.995e-10	5.915e-10
0.0318	4.878e-03	5.132e-11	6.078e-11	4.275e-13	5.063e-13
0.0322	1.051e+01	1.122e-07	1.329e-07	9.027e-10	1.069e-09
0.0322	9.000e-03	9.602e-11	1.137e-10	7.727e-13	9.152e-13
0.0364	3.826e+00	4.699e-08	5.569e-08	2.670e-10	3.164e-10
0.0364	3.275e-03	4.022e-11	4.767e-11	2.285e-13	2.708e-13
0.1221	1.310e-01	5.672e-09	6.326e-09	8.894e-12	9.918e-12

Page : 2  
DOS File: CC300.MS5  
Run Date: June 12, 2002  
Run Time: 10:27:56 AM  
Duration: 00:00:05

CALC 016-01 (mX)  
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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.1365	1.624e-02	7.881e-10	8.735e-10	1.267e-12	1.405e-12
0.2769	8.055e-04	8.034e-11	8.516e-11	1.507e-13	1.597e-13
0.4753	3.322e-02	5.743e-09	5.975e-09	1.127e-11	1.172e-11
0.536	4.390e-05	8.576e-12	8.892e-12	1.682e-14	1.744e-14
0.5632	1.907e-01	3.917e-08	4.056e-08	7.669e-11	7.942e-11
0.5693	3.511e-01	7.291e-08	7.549e-08	1.427e-10	1.477e-10
0.6047	2.221e+00	4.904e-07	5.069e-07	9.567e-10	9.889e-10
0.6616	2.477e+02	5.993e-05	6.181e-05	1.162e-07	1.198e-07
0.692	2.449e-04	6.202e-11	6.390e-11	1.198e-13	1.234e-13
0.6938	4.762e-03	1.209e-09	1.246e-09	2.334e-12	2.405e-12
0.7958	1.943e+00	5.671e-07	5.826e-07	1.079e-09	1.109e-09
0.8019	1.986e-01	5.842e-08	6.000e-08	1.111e-10	1.141e-10
1.0386	2.275e-02	8.701e-09	8.897e-09	1.593e-11	1.629e-11
1.1679	4.096e-02	1.764e-08	1.801e-08	3.155e-11	3.221e-11
1.1732	2.919e+01	1.263e-05	1.289e-05	2.257e-08	2.304e-08
1.3325	2.919e+01	1.437e-05	1.464e-05	2.493e-08	2.540e-08
1.3652	6.917e-02	3.490e-08	3.554e-08	6.018e-11	6.129e-11
TOTALS:	3.313e+02	8.845e-05	9.094e-05	1.678e-07	1.728e-07

MicroShield v5.05 (5.05-00105)  
Stone & Webster

CC100 v16-v17 (2011)

Rev 2, Att 2

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Page : 1  
DOS File: CC100.MS5  
Run Date: June 12, 2002  
Run Time: 10:29:07 AM  
Duration: 00:00:05

File Ref: \_\_\_\_\_  
Date: \_\_\_\_\_  
By: DR  
Checked: \_\_\_\_\_

Case Title: AF 100 m<sup>2</sup>  
Description: Contaminated Concrete - MY nuclide mix  
Geometry: 4 - Rectangular Area - Vertical



#### Source Dimensions

Width 1.0e+3 cm 32 ft 9.7 in  
Height 1.0e+3 cm 32 ft 9.7 in

#### Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	100 cm	500 cm	500 cm
	3 ft 3.4 in	16 ft 4.9 in	16 ft 4.9 in

#### Shields

<u>Shield Name</u>	<u>Material</u>	<u>Density</u>
Air Gap	Air	0.00122

#### Source Input

##### Grouping Method : Actual Photon Energies

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>μCi/cm<sup>2</sup></u>	<u>Bq/cm<sup>2</sup></u>
Ba-137m	2.4800e-009	9.1760e+001	2.4800e-009	9.1760e-005
Co-57	1.3800e-012	5.1060e-002	1.3800e-012	5.1060e-008
Co-60	2.6300e-010	9.7310e+000	2.6300e-010	9.7310e-006
Cs-134	2.0500e-011	7.5850e-001	2.0500e-011	7.5850e-007
Cs-137	2.4800e-009	9.1760e+001	2.4800e-009	9.1760e-005
Fe-55	2.1700e-011	8.0290e-001	2.1700e-011	8.0290e-007
H-3	1.0600e-010	3.9220e+000	1.0600e-010	3.9220e-006
Ni-63	1.6000e-009	5.9200e+001	1.6000e-009	5.9200e-005
Sr-90	1.2600e-011	4.6620e-001	1.2600e-011	4.6620e-007
Y-90	1.2600e-011	4.6620e-001	1.2600e-011	4.6620e-007

#### Buildup

The material reference is : Air Gap

#### Integration Parameters

Z Direction 20  
Y Direction 20

#### Results

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.0318	1.900e+00	4.758e-08	5.366e-08	3.963e-10	4.470e-10
0.0318	1.626e-03	4.073e-11	4.593e-11	3.392e-13	3.826e-13
0.0322	3.505e+00	8.896e-08	1.003e-07	7.160e-10	8.074e-10
0.0322	3.000e-03	7.615e-11	8.588e-11	6.128e-13	6.912e-13
0.0364	1.275e+00	3.708e-08	4.182e-08	2.107e-10	2.376e-10
0.0364	1.092e-03	3.174e-11	3.580e-11	1.803e-13	2.034e-13
0.1221	4.366e-02	4.413e-09	4.765e-09	6.919e-12	7.472e-12

Page : 2  
 DOS File: CC100.MS5  
 Run Date: June 12, 2002  
 Run Time: 10:29:07 AM  
 Duration: 00:00:05

ERIC via e-mail  
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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.1365	5.414e-03	6.128e-10	6.588e-10	9.853e-13	1.059e-12
0.2769	2.685e-04	6.223e-11	6.485e-11	1.167e-13	1.216e-13
0.4753	1.107e-02	4.436e-09	4.562e-09	8.705e-12	8.951e-12
0.536	1.464e-05	6.621e-12	6.792e-12	1.298e-14	1.332e-14
0.5632	6.356e-02	3.023e-08	3.099e-08	5.919e-11	6.067e-11
0.5693	1.170e-01	5.628e-08	5.767e-08	1.101e-10	1.129e-10
0.6047	7.403e-01	3.783e-07	3.873e-07	7.382e-10	7.556e-10
0.6616	8.257e+01	4.622e-05	4.724e-05	8.960e-08	9.158e-08
0.692	8.164e-05	4.782e-11	4.884e-11	9.236e-14	9.432e-14
0.6938	1.587e-03	9.323e-10	9.521e-10	1.800e-12	1.838e-12
0.7958	6.478e-01	4.370e-07	4.454e-07	8.318e-10	8.477e-10
0.8019	6.622e-02	4.502e-08	4.588e-08	8.561e-11	8.724e-11
1.0386	7.585e-03	6.697e-09	6.803e-09	1.226e-11	1.246e-11
1.1679	1.365e-02	1.357e-08	1.377e-08	2.428e-11	2.463e-11
1.1732	9.731e+00	9.717e-06	9.858e-06	1.737e-08	1.762e-08
1.3325	9.731e+00	1.105e-05	1.120e-05	1.917e-08	1.942e-08
1.3652	2.306e-02	2.683e-08	2.718e-08	4.627e-11	4.687e-11
TOTALS:	1.105e+02	6.816e-05	6.952e-05	1.294e-07	1.321e-07

MicroShield v5.05 (5.05-00105)  
Stone & Webster

CALC 016-01 (MST)

REV 2, Att. 2

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File Ref: \_\_\_\_\_

Date: \_\_\_\_\_

By: DR

Checked: \_\_\_\_\_

Page : 1  
DOS File: CC50.MS5  
Run Date: June 12, 2002  
Run Time: 10:31:55 AM  
Duration: 00:00:05

Case Title: AF 50 m<sup>2</sup>  
Description: Contaminated Concrete - MY nuclide mix  
Geometry: 4 - Rectangular Area - Vertical



#### Source Dimensions

Width 707.1 cm 23 ft 2.4 in  
Height 707.1 cm 23 ft 2.4 in

#### Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	100 cm	353.6 cm	353.6 cm
	3 ft 3.4 in	11 ft 7.2 in	11 ft 7.2 in

#### Shields

<u>Shield Name</u>	<u>Material</u>	<u>Density</u>
Air Gap	Air	0.00122

#### Source Input

##### Grouping Method : Actual Photon Energies

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>μCi/cm<sup>2</sup></u>	<u>Bq/cm<sup>2</sup></u>
Ba-137m	1.2400e-009	4.5879e+001	2.4800e-009	9.1760e-005
Co-57	6.8999e-013	2.5530e-002	1.3800e-012	5.1060e-008
Co-60	1.3150e-010	4.8654e+000	2.6300e-010	9.7310e-006
Cs-134	1.0250e-011	3.7924e-001	2.0500e-011	7.5850e-007
Cs-137	1.2400e-009	4.5879e+001	2.4800e-009	9.1760e-005
Fe-55	1.0850e-011	4.0144e-001	2.1700e-011	8.0290e-007
H-3	5.2999e-011	1.9610e+000	1.0600e-010	3.9220e-006
Ni-63	7.9998e-010	2.9599e+001	1.6000e-009	5.9200e-005
Sr-90	6.2999e-012	2.3310e-001	1.2600e-011	4.6620e-007
Y-90	6.2999e-012	2.3310e-001	1.2600e-011	4.6620e-007

#### Buildup

The material reference is : Air Gap

#### Integration Parameters

Z Direction 20  
Y Direction 20

#### Results

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.0318	9.498e-01	3.920e-08	4.324e-08	3.265e-10	3.602e-10
0.0318	8.130e-04	3.355e-11	3.701e-11	2.795e-13	3.083e-13
0.0322	1.752e+00	7.327e-08	8.082e-08	5.896e-10	6.505e-10
0.0322	1.500e-03	6.271e-11	6.918e-11	5.047e-13	5.568e-13
0.0364	6.377e-01	3.047e-08	3.361e-08	1.731e-10	1.909e-10
0.0364	5.459e-04	2.608e-11	2.877e-11	1.482e-13	1.634e-13
0.1221	2.183e-02	3.603e-09	3.835e-09	5.648e-12	6.013e-12

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 DOS File: CC50.MS5  
 Run Date: June 12, 2002  
 Run Time: 10:31:55 AM  
 Duration: 00:00:05

CRIC 016-21 (MY)  
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<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u>	<u>Fluence Rate</u>	<u>Exposure Rate</u>	<u>Exposure Rate</u>
		MeV/cm <sup>2</sup> /sec	MeV/cm <sup>2</sup> /sec	mR/hr	mR/hr
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.1365	2.707e-03	5.001e-10	5.305e-10	8.041e-13	8.530e-13
0.2769	1.343e-04	5.070e-11	5.243e-11	9.511e-14	9.835e-14
0.4753	5.537e-03	3.610e-09	3.693e-09	7.083e-12	7.246e-12
0.536	7.318e-06	5.386e-12	5.499e-12	1.056e-14	1.078e-14
0.5632	3.178e-02	2.459e-08	2.509e-08	4.815e-11	4.912e-11
0.5693	5.852e-02	4.577e-08	4.669e-08	8.958e-11	9.138e-11
0.6047	3.701e-01	3.077e-07	3.136e-07	6.003e-10	6.119e-10
0.6616	4.128e+01	3.758e-05	3.826e-05	7.286e-08	7.416e-08
0.692	4.082e-05	3.888e-11	3.956e-11	7.509e-14	7.639e-14
0.6938	7.936e-04	7.579e-10	7.710e-10	1.463e-12	1.489e-12
0.7958	3.239e-01	3.552e-07	3.607e-07	6.761e-10	6.866e-10
0.8019	3.311e-02	3.659e-08	3.716e-08	6.958e-11	7.066e-11
1.0386	3.792e-03	5.441e-09	5.511e-09	9.962e-12	1.009e-11
1.1679	6.826e-03	1.102e-08	1.115e-08	1.972e-11	1.995e-11
1.1732	4.865e+00	7.892e-06	7.985e-06	1.410e-08	1.427e-08
1.3325	4.865e+00	8.973e-06	9.069e-06	1.557e-08	1.573e-08
1.3652	1.153e-02	2.179e-08	2.202e-08	3.757e-11	3.797e-11
TOTALS:	5.523e+01	5.541e-05	5.630e-05	1.052e-07	1.070e-07

MicroShield v5.05 (5.05-00105)  
Stone & Webster

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File Ref: \_\_\_\_\_

Page : 1  
DOS File: CC36.MS5  
Run Date: June 12, 2002  
Run Time: 10:33:04 AM  
Duration: 00:00:05

Date: \_\_\_\_\_  
By: DR  
Checked: \_\_\_\_\_

Case Title: AF 36 m<sup>2</sup>  
Description: Contaminated Concrete - MY nuclide mix  
Geometry: 4 - Rectangular Area - Vertical



## Source Dimensions

Width 600.0 cm 19 ft 8.2 in  
Height 600.0 cm 19 ft 8.2 in

## Dose Points

	X	Y	Z
# 1	100 cm	300 cm	300 cm
	3 ft 3.4 in	9 ft 10.1 in	9 ft 10.1 in

## Shields

Shield Name	Material	Density
Air Gap	Air	0.00122

## Source Input

Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	$\mu\text{Ci/cm}^2$	Bq/cm <sup>2</sup>
Ba-137m	8.9280e-010	3.3034e+001	2.4800e-009	9.1760e-005
Co-57	4.9680e-013	1.8382e-002	1.3800e-012	5.1060e-008
Co-60	9.4680e-011	3.5032e+000	2.6300e-010	9.7310e-006
Cs-134	7.3800e-012	2.7306e-001	2.0500e-011	7.5850e-007
Cs-137	8.9280e-010	3.3034e+001	2.4800e-009	9.1760e-005
Fe-55	7.8120e-012	2.8904e-001	2.1700e-011	8.0290e-007
H-3	3.8160e-011	1.4119e+000	1.0600e-010	3.9220e-006
Ni-63	5.7600e-010	2.1312e+001	1.6000e-009	5.9200e-005
Sr-90	4.5360e-012	1.6783e-001	1.2600e-011	4.6620e-007
Y-90	4.5360e-012	1.6783e-001	1.2600e-011	4.6620e-007

## Buildup

The material reference is : Air Gap

## Integration Parameters

Z Direction 20  
Y Direction 20

## Results

Energy MeV	Activity photons/sec	Fluence Rate		Exposure Rate	
		No Buildup	With Buildup	No Buildup	With Buildup
0.0318	6.839e-01	3.518e-08	3.848e-08	2.931e-10	3.206e-10
0.0318	5.854e-04	3.012e-11	3.294e-11	2.509e-13	2.744e-13
0.0322	1.262e+00	6.576e-08	7.192e-08	5.292e-10	5.788e-10
0.0322	1.080e-03	5.629e-11	6.157e-11	4.530e-13	4.955e-13
0.0364	4.592e-01	2.732e-08	2.988e-08	1.552e-10	1.698e-10
0.0364	3.930e-04	2.339e-11	2.557e-11	1.329e-13	1.453e-13
0.1221	1.572e-02	3.222e-09	3.411e-09	5.052e-12	5.348e-12



Page : 2  
 DOS File: CC36.MS5  
 Run Date: June 12, 2002  
 Run Time: 10:33:04 AM  
 Duration: 00:00:05

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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.1365	1.949e-03	4.472e-10	4.720e-10	7.192e-13	7.589e-13
0.2769	9.666e-05	4.531e-11	4.672e-11	8.500e-14	8.764e-14
0.4753	3.987e-03	3.225e-09	3.292e-09	6.327e-12	6.460e-12
0.536	5.269e-06	4.811e-12	4.903e-12	9.435e-15	9.616e-15
0.5632	2.288e-02	2.196e-08	2.237e-08	4.300e-11	4.380e-11
0.5693	4.213e-02	4.088e-08	4.163e-08	8.001e-11	8.148e-11
0.6047	2.665e-01	2.748e-07	2.796e-07	5.362e-10	5.456e-10
0.6616	2.972e+01	3.356e-05	3.411e-05	6.507e-08	6.613e-08
0.692	2.939e-05	3.472e-11	3.527e-11	6.706e-14	6.812e-14
0.6938	5.714e-04	6.769e-10	6.875e-10	1.307e-12	1.327e-12
0.7958	2.332e-01	3.172e-07	3.217e-07	6.037e-10	6.122e-10
0.8019	2.384e-02	3.267e-08	3.314e-08	6.213e-11	6.301e-11
1.0386	2.731e-03	4.857e-09	4.914e-09	8.894e-12	8.998e-12
1.1679	4.915e-03	9.840e-09	9.946e-09	1.760e-11	1.779e-11
1.1732	3.503e+00	7.045e-06	7.121e-06	1.259e-08	1.273e-08
1.3325	3.503e+00	8.009e-06	8.087e-06	1.390e-08	1.403e-08
1.3652	8.301e-03	1.945e-08	1.963e-08	3.354e-11	3.386e-11
TOTALS:	3.976e+01	4.947e-05	5.020e-05	9.393e-08	9.538e-08

MicroShield v5.05 (5.05-00105)  
Stone & Webster

Calc 016-011 (111)

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File Ref: \_\_\_\_\_

Date: \_\_\_\_\_

By: DR

Checked: \_\_\_\_\_

Page : 1  
DOS File: CC25.MS5  
Run Date: June 12, 2002  
Run Time: 10:34:39 AM  
Duration: 00:00:05

Case Title: AF 25 m<sup>2</sup>  
Description: Contaminated Concrete - MY nuclide mix  
Geometry: 4 - Rectangular Area - Vertical



#### Source Dimensions

Width 500.0 cm 16 ft 4.9 in  
Height 500.0 cm 16 ft 4.9 in

#### Dose Points

#	X	Y	Z
1	100 cm	250 cm	250 cm
	3 ft 3.4 in	8 ft 2.4 in	8 ft 2.4 in

#### Shields

Shield Name	Material	Density
Air Gap	Air	0.00122

#### Source Input

##### Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^2$	Bq/cm <sup>2</sup>
Ba-137m	6.2000e-010	2.2940e+001	2.4800e-009	9.1760e-005
Co-57	3.4500e-013	1.2765e-002	1.3800e-012	5.1060e-008
Co-60	6.5750e-011	2.4328e+000	2.6300e-010	9.7310e-006
Cs-134	5.1250e-012	1.8963e-001	2.0500e-011	7.5850e-007
Cs-137	6.2000e-010	2.2940e+001	2.4800e-009	9.1760e-005
Fe-55	5.4250e-012	2.0073e-001	2.1700e-011	8.0290e-007
H-3	2.6500e-011	9.8050e-001	1.0600e-010	3.9220e-006
Ni-63	4.0000e-010	1.4800e+001	1.6000e-009	5.9200e-005
Sr-90	3.1500e-012	1.1655e-001	1.2600e-011	4.6620e-007
Y-90	3.1500e-012	1.1655e-001	1.2600e-011	4.6620e-007

#### Buildup

The material reference is : Air Gap

#### Integration Parameters

Z Direction 20  
Y Direction 20

#### Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm <sup>2</sup> /sec	Fluence Rate		Exposure Rate	
			No Buildup	With Buildup	No Buildup	With Buildup
0.0318	4.749e-01	3.077e-08	3.338e-08	2.563e-10	2.780e-10	
0.0318	4.065e-04	2.634e-11	2.857e-11	2.194e-13	2.380e-13	
0.0322	8.762e-01	5.750e-08	6.238e-08	4.628e-10	5.020e-10	
0.0322	7.500e-04	4.922e-11	5.339e-11	3.961e-13	4.297e-13	
0.0364	3.189e-01	2.387e-08	2.589e-08	1.356e-10	1.471e-10	
0.0364	2.729e-04	2.043e-11	2.216e-11	1.161e-13	1.259e-13	
0.1221	1.092e-02	2.808e-09	2.957e-09	4.403e-12	4.637e-12	

Page : 2  
 DOS File: CC25.MS5  
 Run Date: June 12, 2002  
 Run Time: 10:34:39 AM  
 Duration: 00:00:05

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<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm <sup>2</sup> /sec No Buildup	<u>Fluence Rate</u> MeV/cm <sup>2</sup> /sec With Buildup	<u>Exposure Rate</u> mR/hr No Buildup	<u>Exposure Rate</u> mR/hr With Buildup
0.1365	1.353e-03	3.897e-10	4.092e-10	6.267e-13	6.580e-13
0.2769	6.713e-05	3.946e-11	4.057e-11	7.403e-14	7.611e-14
0.4753	2.769e-03	2.807e-09	2.860e-09	5.508e-12	5.612e-12
0.536	3.659e-06	4.187e-12	4.260e-12	8.212e-15	8.354e-15
0.5632	1.589e-02	1.912e-08	1.944e-08	3.743e-11	3.806e-11
0.5693	2.926e-02	3.558e-08	3.617e-08	6.964e-11	7.080e-11
0.6047	1.851e-01	2.392e-07	2.430e-07	4.666e-10	4.740e-10
0.6616	2.064e+01	2.921e-05	2.964e-05	5.662e-08	5.746e-08
0.692	2.041e-05	3.022e-11	3.065e-11	5.835e-14	5.919e-14
0.6938	3.968e-04	5.890e-10	5.974e-10	1.137e-12	1.153e-12
0.7958	1.619e-01	2.760e-07	2.795e-07	5.253e-10	5.320e-10
0.8019	1.655e-02	2.843e-08	2.879e-08	5.406e-11	5.475e-11
1.0386	1.896e-03	4.226e-09	4.270e-09	7.737e-12	7.819e-12
1.1679	3.413e-03	8.560e-09	8.643e-09	1.531e-11	1.546e-11
1.1732	2.433e+00	6.129e-06	6.188e-06	1.095e-08	1.106e-08
1.3325	2.433e+00	6.966e-06	7.028e-06	1.209e-08	1.219e-08
1.3652	5.765e-03	1.692e-08	1.706e-08	2.917e-11	2.942e-11
TOTALS:	2.761e+01	4.305e-05	4.362e-05	8.173e-08	8.288e-08

MicroShield v5.05 (5.05-00105)  
Stone & Webster

CC16 016-01 (M1)  
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File Ref:

Page : 1  
DOS File: CC16.MS5  
Run Date: June 12, 2002  
Run Time: 10:35:58 AM  
Duration: 00:00:05

Date: \_\_\_\_\_  
By: DR  
Checked: \_\_\_\_\_

Case Title: AF 16 m<sup>2</sup>  
Description: Contaminated Concrete - MY nuclide mix  
Geometry: 4 - Rectangular Area - Vertical



Source Dimensions

Width 400.0 cm 13 ft 1.5 in  
Height 400.0 cm 13 ft 1.5 in

Dose Points

#	X	Y	Z
1	100 cm	200 cm	200 cm
	3 ft 3.4 in	6 ft 6.7 in	6 ft 6.7 in

Shields

Shield Name	Material	Density
Air Gap	Air	0.00122

Source Input

Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^2$	Bq/cm <sup>2</sup>
Ba-137m	3.9680e-010	1.4682e+001	2.4800e-009	9.1760e-005
Co-57	2.2080e-013	8.1696e-003	1.3800e-012	5.1060e-008
Co-60	4.2080e-011	1.5570e+000	2.6300e-010	9.7310e-006
Cs-134	3.2800e-012	1.2136e-001	2.0500e-011	7.5850e-007
Cs-137	3.9680e-010	1.4682e+001	2.4800e-009	9.1760e-005
Fe-55	3.4720e-012	1.2846e-001	2.1700e-011	8.0290e-007
H-3	1.6960e-011	6.2752e-001	1.0600e-010	3.9220e-006
Ni-63	2.5600e-010	9.4720e+000	1.6000e-009	5.9200e-005
Sr-90	2.0160e-012	7.4592e-002	1.2600e-011	4.6620e-007
Y-90	2.0160e-012	7.4592e-002	1.2600e-011	4.6620e-007

Buildup

The material reference is : Air Gap

Integration Parameters

Z Direction 20  
Y Direction 20

Results

Energy MeV	Activity photons/sec	Fluence Rate		Exposure Rate	
		No Buildup	With Buildup	No Buildup	With Buildup
0.0318	3.040e-01	2.552e-08	2.745e-08	2.126e-10	2.287e-10
0.0318	2.602e-04	2.185e-11	2.350e-11	1.820e-13	1.957e-13
0.0322	5.608e-01	4.769e-08	5.129e-08	3.838e-10	4.128e-10
0.0322	4.800e-04	4.082e-11	4.391e-11	3.285e-13	3.533e-13
0.0364	2.041e-01	1.978e-08	2.127e-08	1.124e-10	1.208e-10
0.0364	1.747e-04	1.693e-11	1.821e-11	9.619e-14	1.034e-13
0.1221	6.986e-03	2.321e-09	2.431e-09	3.639e-12	3.811e-12

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DOS File: CC16.MS5  
Run Date: June 12, 2002  
Run Time: 10:35:58 AM  
Duration: 00:00:05

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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.1365	8.662e-04	3.221e-10	3.364e-10	5.179e-13	5.410e-13
0.2769	4.296e-05	3.259e-11	3.341e-11	6.113e-14	6.267e-14
0.4753	1.772e-03	2.317e-09	2.356e-09	4.546e-12	4.624e-12
0.536	2.342e-06	3.456e-12	3.510e-12	6.778e-15	6.883e-15
0.5632	1.017e-02	1.578e-08	1.601e-08	3.089e-11	3.135e-11
0.5693	1.873e-02	2.937e-08	2.980e-08	5.747e-11	5.833e-11
0.6047	1.184e-01	1.974e-07	2.002e-07	3.851e-10	3.906e-10
0.6616	1.321e+01	2.410e-05	2.442e-05	4.673e-08	4.734e-08
0.692	1.306e-05	2.493e-11	2.525e-11	4.815e-14	4.877e-14
0.6938	2.540e-04	4.860e-10	4.923e-10	9.384e-13	9.504e-13
0.7958	1.036e-01	2.277e-07	2.303e-07	4.334e-10	4.384e-10
0.8019	1.059e-02	2.346e-08	2.373e-08	4.461e-11	4.512e-11
1.0386	1.214e-03	3.486e-09	3.519e-09	6.383e-12	6.443e-12
1.1679	2.184e-03	7.060e-09	7.122e-09	1.263e-11	1.274e-11
1.1732	1.557e+00	5.055e-06	5.099e-06	9.034e-09	9.113e-09
1.3325	1.557e+00	5.746e-06	5.791e-06	9.969e-09	1.005e-08
1.3652	3.689e-03	1.395e-08	1.406e-08	2.406e-11	2.425e-11
TOTALS:	1.767e+01	3.552e-05	3.594e-05	6.744e-08	6.828e-08

MicroShield v5.05 (5.05-00105)  
Stone & Webster

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Page : 1  
DOS File: CC10.MS5  
Run Date: June 12, 2002  
Run Time: 10:36:56 AM  
Duration: 00:00:05

File Ref: \_\_\_\_\_  
Date: \_\_\_\_\_  
By: DR  
Checked: \_\_\_\_\_

Case Title: AF 10 m<sup>2</sup>  
Description: Contaminated Concrete - MY nuclide mix  
Geometry: 4 - Rectangular Area - Vertical



## Source Dimensions

Width 316.2 cm 10 ft 4.5 in  
Height 316.2 cm 10 ft 4.5 in

## Dose Points

	X	Y	Z
# 1	100 cm	158.1 cm	158.1 cm
	3 ft 3.4 in	5 ft 2.2 in	5 ft 2.2 in

## Shields

Shield Name	Material	Density
Air Gap	Air	0.00122

## Source Input

## Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^2$	Bq/cm <sup>2</sup>
Ba-137m	2.4796e-010	9.1744e+000	2.4800e-009	9.1760e-005
Co-57	1.3798e-013	5.1051e-003	1.3800e-012	5.1060e-008
Co-60	2.6295e-011	9.7293e-001	2.6300e-010	9.7310e-006
Cs-134	2.0496e-012	7.5837e-002	2.0500e-011	7.5850e-007
Cs-137	2.4796e-010	9.1744e+000	2.4800e-009	9.1760e-005
Fe-55	2.1696e-012	8.0276e-002	2.1700e-011	8.0290e-007
H-3	1.0598e-011	3.9213e-001	1.0600e-010	3.9220e-006
Ni-63	1.5997e-010	5.9190e+000	1.6000e-009	5.9200e-005
Sr-90	1.2598e-012	4.6612e-002	1.2600e-011	4.6620e-007
Y-90	1.2598e-012	4.6612e-002	1.2600e-011	4.6620e-007

## Buildup

The material reference is : Air Gap

## Integration Parameters

Z Direction 20  
Y Direction 20

## Results

Energy MeV	Activity photons/sec	Fluence Rate		Exposure Rate	
		No Buildup	With Buildup	No Buildup	With Buildup
0.0318	1.899e-01	2.032e-08	2.170e-08	1.693e-10	1.807e-10
0.0318	1.626e-04	1.739e-11	1.857e-11	1.449e-13	1.547e-13
0.0322	3.504e-01	3.796e-08	4.054e-08	3.055e-10	3.262e-10
0.0322	3.000e-04	3.250e-11	3.470e-11	2.615e-13	2.793e-13
0.0364	1.275e-01	1.573e-08	1.680e-08	8.939e-11	9.543e-11
0.0364	1.092e-04	1.347e-11	1.438e-11	7.652e-14	8.168e-14
0.1221	4.365e-03	1.842e-09	1.920e-09	2.888e-12	3.011e-12

Page : 2  
 DOS File: CC10.MS5  
 Run Date: June 12, 2002  
 Run Time: 10:36:56 AM  
 Duration: 00:00:05

Case 016-77 (MT)

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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.1365	5.413e-04	2.556e-10	2.658e-10	4.110e-13	4.275e-13
0.2769	2.685e-05	2.585e-11	2.643e-11	4.849e-14	4.959e-14
0.4753	1.107e-03	1.837e-09	1.865e-09	3.605e-12	3.660e-12
0.536	1.463e-06	2.740e-12	2.778e-12	5.373e-15	5.448e-15
0.5632	6.355e-03	1.251e-08	1.268e-08	2.449e-11	2.482e-11
0.5693	1.170e-02	2.328e-08	2.359e-08	4.556e-11	4.617e-11
0.6047	7.402e-02	1.565e-07	1.585e-07	3.053e-10	3.092e-10
0.6616	8.255e+00	1.911e-05	1.933e-05	3.704e-08	3.748e-08
0.692	8.163e-06	1.976e-11	1.999e-11	3.817e-14	3.861e-14
0.6938	1.587e-04	3.853e-10	3.897e-10	7.438e-13	7.524e-13
0.7958	6.476e-02	1.805e-07	1.824e-07	3.435e-10	3.471e-10
0.8019	6.621e-03	1.859e-08	1.878e-08	3.535e-11	3.572e-11
1.0386	7.584e-04	2.762e-09	2.786e-09	5.058e-12	5.101e-12
1.1679	1.365e-03	5.595e-09	5.639e-09	1.001e-11	1.009e-11
1.1732	9.729e-01	4.006e-06	4.037e-06	7.158e-09	7.214e-09
1.3325	9.729e-01	4.553e-06	4.585e-06	7.899e-09	7.955e-09
1.3652	2.305e-03	1.105e-08	1.113e-08	1.906e-11	1.920e-11
TOTALS:	1.104e+01	2.815e-05	2.845e-05	5.346e-08	5.406e-08

MicroShield v5.05 (5.05-00105)  
Stone & Webster

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Page : 1  
DOS File: CC8.MS5  
Run Date: June 12, 2002  
Run Time: 10:38:20 AM  
Duration: 00:00:05

File Ref: \_\_\_\_\_  
Date: \_\_\_\_\_  
By: DA  
Checked: \_\_\_\_\_

Case Title: AF 8 m<sup>2</sup>  
Description: Contaminated Concrete - MY nuclide mix  
Geometry: 4 - Rectangular Area - Vertical



## Source Dimensions

Width 282.8 cm 9 ft 3.3 in  
Height 282.8 cm 9 ft 3.3 in

## Dose Points

	X	Y	Z
# 1	100 cm	141.4 cm	141.4 cm
	3 ft 3.4 in	4 ft 7.7 in	4 ft 7.7 in

## Shields

Shield Name	Material	Density
Air Gap	Air	0.00122

## Source Input

## Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^2$	Bq/cm <sup>2</sup>
Ba-137m	1.9834e-010	7.3386e+000	2.4800e-009	9.1760e-005
Co-57	1.1037e-013	4.0836e-003	1.3800e-012	5.1060e-008
Co-60	2.1034e-011	7.7824e-001	2.6300e-010	9.7310e-006
Cs-134	1.6395e-012	6.0662e-002	2.0500e-011	7.5850e-007
Cs-137	1.9834e-010	7.3386e+000	2.4800e-009	9.1760e-005
Fe-55	1.7355e-012	6.4213e-002	2.1700e-011	8.0290e-007
H-3	8.4774e-012	3.1367e-001	1.0600e-010	3.9220e-006
Ni-63	1.2796e-010	4.7346e+000	1.6000e-009	5.9200e-005
Sr-90	1.0077e-012	3.7285e-002	1.2600e-011	4.6620e-007
Y-90	1.0077e-012	3.7285e-002	1.2600e-011	4.6620e-007

## Buildup

The material reference is : Air Gap

## Integration Parameters

Z Direction 20  
Y Direction 20

## Results

Energy MeV	Activity photons/sec	Fluence Rate		Exposure Rate	
		MeV/cm <sup>2</sup> /sec No Buildup	MeV/cm <sup>2</sup> /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.0318	1.519e-01	1.801e-08	1.918e-08	1.501e-10	1.598e-10
0.0318	1.300e-04	1.542e-11	1.642e-11	1.284e-13	1.367e-13
0.0322	2.803e-01	3.366e-08	3.583e-08	2.709e-10	2.884e-10
0.0322	2.399e-04	2.881e-11	3.067e-11	2.319e-13	2.469e-13
0.0364	1.020e-01	1.394e-08	1.484e-08	7.922e-11	8.433e-11
0.0364	8.732e-05	1.194e-11	1.270e-11	6.781e-14	7.218e-14
0.1221	3.492e-03	1.631e-09	1.697e-09	2.558e-12	2.661e-12



Page : 2  
 DOS File: CC8.MS5  
 Run Date: June 12, 2002  
 Run Time: 10:38:20 AM  
 Duration: 00:00:05

CALL 016-0217177  
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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.1365	4.330e-04	2.263e-10	2.350e-10	3.639e-13	3.779e-13
0.2769	2.147e-05	2.288e-11	2.338e-11	4.293e-14	4.385e-14
0.4753	8.857e-04	1.626e-09	1.650e-09	3.191e-12	3.237e-12
0.536	1.170e-06	2.425e-12	2.457e-12	4.756e-15	4.819e-15
0.5632	5.083e-03	1.107e-08	1.121e-08	2.167e-11	2.195e-11
0.5693	9.360e-03	2.061e-08	2.087e-08	4.033e-11	4.084e-11
0.6047	5.921e-02	1.385e-07	1.402e-07	2.702e-10	2.735e-10
0.6616	6.603e+00	1.691e-05	1.710e-05	3.278e-08	3.315e-08
0.692	6.530e-06	1.749e-11	1.768e-11	3.378e-14	3.415e-14
0.6938	1.269e-04	3.410e-10	3.447e-10	6.583e-13	6.655e-13
0.7958	5.181e-02	1.597e-07	1.613e-07	3.040e-10	3.070e-10
0.8019	5.296e-03	1.645e-08	1.662e-08	3.129e-11	3.159e-11
1.0386	6.066e-04	2.444e-09	2.464e-09	4.476e-12	4.512e-12
1.1679	1.092e-03	4.951e-09	4.988e-09	8.856e-12	8.922e-12
1.1732	7.782e-01	3.545e-06	3.571e-06	6.334e-09	6.382e-09
1.3325	7.782e-01	4.029e-06	4.056e-06	6.989e-09	7.037e-09
1.3652	1.844e-03	9.781e-09	9.847e-09	1.687e-11	1.698e-11
TOTALS:	8.834e+00	2.492e-05	2.517e-05	4.731e-08	4.782e-08

MicroShield v5.05 (5.05-00105)  
Stone & Webster

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Page : 1  
DOS File: CC4.MS5  
Run Date: June 12, 2002  
Run Time: 10:39:24 AM  
Duration: 00:00:05

File Ref: \_\_\_\_\_  
Date: \_\_\_\_\_  
By: DR  
Checked: \_\_\_\_\_

Case Title: AF 4 m<sup>2</sup>  
Description: Contaminated Concrete - MY nuclide mix  
Geometry: 4 - Rectangular Area - Vertical



#### Source Dimensions

Width	200.0 cm	6 ft 6.7 in
Height	200.0 cm	6 ft 6.7 in

#### Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	100 cm	100 cm	100 cm
	3 ft 3.4 in	3 ft 3.4 in	3 ft 3.4 in

#### Shields

<u>Shield Name</u>	<u>Material</u>	<u>Density</u>
Air Gap	Air	0.00122

#### Source Input

##### Grouping Method : Actual Photon Energies

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>μCi/cm²</u>	<u>Bq/cm²</u>
Ba-137m	9.9200e-011	3.6704e+000	2.4800e-009	9.1760e-005
Co-57	5.5200e-014	2.0424e-003	1.3800e-012	5.1060e-008
Co-60	1.0520e-011	3.8924e-001	2.6300e-010	9.7310e-006
Cs-134	8.2000e-013	3.0340e-002	2.0500e-011	7.5850e-007
Cs-137	9.9200e-011	3.6704e+000	2.4800e-009	9.1760e-005
Fe-55	8.6800e-013	3.2116e-002	2.1700e-011	8.0290e-007
H-3	4.2400e-012	1.5688e-001	1.0600e-010	3.9220e-006
Ni-63	6.4000e-011	2.3680e+000	1.6000e-009	5.9200e-005
Sr-90	5.0400e-013	1.8648e-002	1.2600e-011	4.6620e-007
Y-90	5.0400e-013	1.8648e-002	1.2600e-011	4.6620e-007

#### Buildup

The material reference is : Air Gap

#### Integration Parameters

Z Direction	20
Y Direction	20

#### Results

<u>Energy</u>	<u>Activity</u>	<u>Fluence Rate</u>	<u>Fluence Rate</u>	<u>Exposure Rate</u>	<u>Exposure Rate</u>
<u>MeV</u>	<u>photons/sec</u>	<u>MeV/cm²/sec</u>	<u>MeV/cm²/sec</u>	<u>mR/hr</u>	<u>mR/hr</u>
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.0318	7.599e-02	1.176e-08	1.243e-08	9.796e-11	1.036e-10
0.0318	6.504e-05	1.007e-11	1.064e-11	8.385e-14	8.864e-14
0.0322	1.402e-01	2.197e-08	2.323e-08	1.768e-10	1.869e-10
0.0322	1.200e-04	1.881e-11	1.988e-11	1.514e-13	1.600e-13
0.0364	5.102e-02	9.095e-09	9.613e-09	5.167e-11	5.462e-11
0.0364	4.367e-05	7.785e-12	8.229e-12	4.423e-14	4.675e-14
0.1221	1.746e-03	1.062e-09	1.100e-09	1.665e-12	1.724e-12

Page : 2  
 DOS File: CC4.MS5  
 Run Date: June 12, 2002  
 Run Time: 10:39:24 AM  
 Duration: 00:00:05

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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.1365	2.166e-04	1.473e-10	1.523e-10	2.369e-13	2.449e-13
0.2769	1.074e-05	1.489e-11	1.517e-11	2.792e-14	2.846e-14
0.4753	4.430e-04	1.057e-09	1.071e-09	2.074e-12	2.101e-12
0.536	5.854e-07	1.577e-12	1.595e-12	3.092e-15	3.129e-15
0.5632	2.542e-03	7.197e-09	7.279e-09	1.409e-11	1.425e-11
0.5693	4.681e-03	1.340e-08	1.355e-08	2.622e-11	2.651e-11
0.6047	2.961e-02	9.003e-08	9.100e-08	1.756e-10	1.775e-10
0.6616	3.303e+00	1.099e-05	1.110e-05	2.131e-08	2.152e-08
0.692	3.266e-06	1.137e-11	1.148e-11	2.196e-14	2.217e-14
0.6938	6.349e-05	2.216e-10	2.238e-10	4.279e-13	4.321e-13
0.7958	2.591e-02	1.038e-07	1.047e-07	1.976e-10	1.993e-10
0.8019	2.649e-03	1.069e-08	1.079e-08	2.034e-11	2.051e-11
1.0386	3.034e-04	1.589e-09	1.600e-09	2.909e-12	2.930e-12
1.1679	5.461e-04	3.217e-09	3.239e-09	5.755e-12	5.793e-12
1.1732	3.892e-01	2.303e-06	2.319e-06	4.116e-09	4.144e-09
1.3325	3.892e-01	2.618e-06	2.633e-06	4.541e-09	4.569e-09
1.3652	9.223e-04	6.356e-09	6.393e-09	1.096e-11	1.102e-11
TOTALS:	4.418e+00	1.619e-05	1.634e-05	3.075e-08	3.104e-08

MicroShield v5.05 (5.05-00105)  
Stone & Webster

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File Ref: \_\_\_\_\_  
Date: \_\_\_\_\_  
By: DR  
Checked: \_\_\_\_\_

Page : 1  
DOS File: CC3.MS5  
Run Date: June 12, 2002  
Run Time: 10:51:35 AM  
Duration: 00:00:05

Case Title: AF 3 m<sup>2</sup>  
Description: Contaminated Concrete - MY nuclide mix  
Geometry: 4 - Rectangular Area - Vertical



## Source Dimensions

Width	173.2 cm	5 ft 8.2 in
Height	173.2 cm	5 ft 8.2 in

## Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	100 cm	86.6 cm	86.6 cm
	3 ft 3.4 in	2 ft 10.1 in	2 ft 10.1 in

## Shields

<u>Shield Name</u>	<u>Material</u>	<u>Density</u>
Air Gap	Air	0.00122

## Source Input

## Grouping Method : Actual Photon Energies

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>μCi/cm<sup>2</sup></u>	<u>Bq/cm<sup>2</sup></u>
Ba-137m	7.4396e-011	2.7526e+000	2.4800e-009	9.1760e-005
Co-57	4.1398e-014	1.5317e-003	1.3800e-012	5.1060e-008
Co-60	7.8895e-012	2.9191e-001	2.6300e-010	9.7310e-006
Cs-134	6.1496e-013	2.2754e-002	2.0500e-011	7.5850e-007
Cs-137	7.4396e-011	2.7526e+000	2.4800e-009	9.1760e-005
Fe-55	6.5096e-013	2.4086e-002	2.1700e-011	8.0290e-007
H-3	3.1798e-012	1.1765e-001	1.0600e-010	3.9220e-006
Ni-63	4.7997e-011	1.7759e+000	1.6000e-009	5.9200e-005
Sr-90	3.7798e-013	1.3985e-002	1.2600e-011	4.6620e-007
Y-90	3.7798e-013	1.3985e-002	1.2600e-011	4.6620e-007

## Buildup

The material reference is : Air Gap

## Integration Parameters

Z Direction	20
Y Direction	20

## Results

<u>Energy</u>	<u>Activity</u>	<u>Fluence Rate</u>	<u>Fluence Rate</u>	<u>Exposure Rate</u>	<u>Exposure Rate</u>
<u>MeV</u>	<u>photons/sec</u>	<u>MeV/cm<sup>2</sup>/sec</u>	<u>MeV/cm<sup>2</sup>/sec</u>	<u>mR/hr</u>	<u>mR/hr</u>
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.0318	5.699e-02	9.622e-09	1.015e-08	8.015e-11	8.454e-11
0.0318	4.878e-05	8.236e-12	8.688e-12	6.860e-14	7.237e-14
0.0322	1.051e-01	1.797e-08	1.896e-08	1.447e-10	1.526e-10
0.0322	9.000e-05	1.539e-11	1.623e-11	1.238e-13	1.306e-13
0.0364	3.826e-02	7.439e-09	7.846e-09	4.227e-11	4.458e-11
0.0364	3.275e-05	6.368e-12	6.716e-12	3.618e-14	3.816e-14
0.1221	1.310e-03	8.678e-10	8.977e-10	1.361e-12	1.408e-12

Page : 2  
 DOS File: CC3.MS5  
 Run Date: June 12, 2002  
 Run Time: 10:51:35 AM  
 Duration: 00:00:05

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<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm <sup>2</sup> /sec <u>No Buildup</u>	<u>Fluence Rate</u> MeV/cm <sup>2</sup> /sec <u>With Buildup</u>	<u>Exposure Rate</u> mR/hr <u>No Buildup</u>	<u>Exposure Rate</u> mR/hr <u>With Buildup</u>
0.1365	1.624e-04	1.204e-10	1.243e-10	1.936e-13	1.999e-13
0.2769	8.055e-06	1.216e-11	1.239e-11	2.282e-14	2.324e-14
0.4753	3.322e-04	8.639e-10	8.746e-10	1.695e-12	1.716e-12
0.536	4.390e-07	1.288e-12	1.303e-12	2.526e-15	2.555e-15
0.5632	1.907e-03	5.881e-09	5.945e-09	1.151e-11	1.164e-11
0.5693	3.511e-03	1.095e-08	1.106e-08	2.142e-11	2.165e-11
0.6047	2.221e-02	7.356e-08	7.433e-08	1.435e-10	1.450e-10
0.6616	2.477e+00	8.981e-06	9.068e-06	1.741e-08	1.758e-08
0.692	2.449e-06	9.290e-12	9.377e-12	1.794e-14	1.811e-14
0.6938	4.762e-05	1.811e-10	1.828e-10	3.496e-13	3.529e-13
0.7958	1.943e-02	8.483e-08	8.554e-08	1.614e-10	1.628e-10
0.8019	1.986e-03	8.738e-09	8.811e-09	1.662e-11	1.675e-11
1.0386	2.275e-04	1.298e-09	1.307e-09	2.376e-12	2.393e-12
1.1679	4.096e-04	2.628e-09	2.645e-09	4.702e-12	4.732e-12
1.1732	2.919e-01	1.882e-06	1.894e-06	3.363e-09	3.384e-09
1.3325	2.919e-01	2.139e-06	2.151e-06	3.710e-09	3.732e-09
1.3652	6.917e-04	5.192e-09	5.222e-09	8.954e-12	9.005e-12
TOTALS:	3.313e+00	1.323e-05	1.335e-05	2.513e-08	2.536e-08

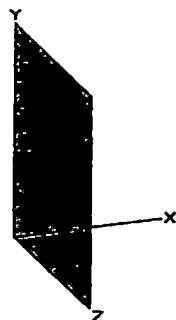
MicroShield v5.05 (5.05-00105)  
Stone & Webster

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Page : 1  
DOS File: CC2.MS5  
Run Date: June 12, 2002  
Run Time: 10:59:23 AM  
Duration: 00:00:05

File Ref: \_\_\_\_\_  
Date: \_\_\_\_\_  
By: DR  
Checked: \_\_\_\_\_

Case Title: AF 2 m<sup>2</sup>  
Description: Contaminated Concrete - MY nuclide mix  
Geometry: 4 - Rectangular Area - Vertical



## Source Dimensions

Width 141.4 cm 4 ft 7.7 in  
Height 141.4 cm 4 ft 7.7 in

## Dose Points

#	X	Y	Z
1	100 cm	70.71 cm	70.71 cm
	3 ft 3.4 in	2 ft 3.8 in	2 ft 3.8 in

## Shields

Shield Name	Material	Density
Air Gap	Air	0.00122

## Source Input

## Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^2$	Bq/cm <sup>2</sup>
Ba-137m	4.9585e-011	1.8346e+000	2.4800e-009	9.1760e-005
Co-57	2.7592e-014	1.0209e-003	1.3800e-012	5.1060e-008
Co-60	5.2584e-012	1.9456e-001	2.6300e-010	9.7310e-006
Cs-134	4.0988e-013	1.5165e-002	2.0500e-011	7.5850e-007
Cs-137	4.9585e-011	1.8346e+000	2.4800e-009	9.1760e-005
Fe-55	4.3387e-013	1.6053e-002	2.1700e-011	8.0290e-007
H-3	2.1194e-012	7.8416e-002	1.0600e-010	3.9220e-006
Ni-63	3.1990e-011	1.1836e+000	1.6000e-009	5.9200e-005
Sr-90	2.5192e-013	9.3212e-003	1.2600e-011	4.6620e-007
Y-90	2.5192e-013	9.3212e-003	1.2600e-011	4.6620e-007

## Buildup

The material reference is : Air Gap

## Integration Parameters

Z Direction 20  
Y Direction 20

## Results

Energy MeV	Activity photons/sec	Fluence Rate		Exposure Rate	
		MeV/cm <sup>2</sup> /sec No Buildup	MeV/cm <sup>2</sup> /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.0318	3.798e-02	7.091e-09	7.462e-09	5.906e-11	6.215e-11
0.0318	3.251e-05	6.069e-12	6.387e-12	5.056e-14	5.320e-14
0.0322	7.008e-02	1.325e-08	1.394e-08	1.066e-10	1.122e-10
0.0322	5.999e-05	1.134e-11	1.193e-11	9.125e-14	9.602e-14
0.0364	2.550e-02	5.481e-09	5.766e-09	3.114e-11	3.276e-11
0.0364	2.183e-05	4.691e-12	4.936e-12	2.665e-14	2.804e-14
0.1221	8.730e-04	6.389e-10	6.599e-10	1.002e-12	1.035e-12

Page : 2  
 DOS File: CC2.MS5  
 Run Date: June 12, 2002  
 Run Time: 10:59:23 AM  
 Duration: 00:00:05

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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.1365	1.082e-04	8.864e-11	9.138e-11	1.425e-13	1.469e-13
0.2769	5.369e-06	8.954e-12	9.110e-12	1.680e-14	1.709e-14
0.4753	2.214e-04	6.358e-10	6.433e-10	1.248e-12	1.262e-12
0.536	2.926e-07	9.481e-13	9.583e-13	1.859e-15	1.879e-15
0.5632	1.271e-03	4.328e-09	4.373e-09	8.473e-12	8.562e-12
0.5693	2.340e-03	8.055e-09	8.139e-09	1.576e-11	1.593e-11
0.6047	1.480e-02	5.413e-08	5.467e-08	1.056e-10	1.067e-10
0.6616	1.651e+00	6.609e-06	6.670e-06	1.281e-08	1.293e-08
0.692	1.632e-06	6.836e-12	6.897e-12	1.320e-14	1.332e-14
0.6938	3.174e-05	1.333e-10	1.345e-10	2.573e-13	2.596e-13
0.7958	1.295e-02	6.242e-08	6.292e-08	1.188e-10	1.197e-10
0.8019	1.324e-03	6.430e-09	6.481e-09	1.223e-11	1.232e-11
1.0386	1.517e-04	9.550e-10	9.613e-10	1.749e-12	1.760e-12
1.1679	2.730e-04	1.934e-09	1.946e-09	3.459e-12	3.480e-12
1.1732	1.946e-01	1.385e-06	1.393e-06	2.474e-09	2.489e-09
1.3325	1.946e-01	1.573e-06	1.582e-06	2.730e-09	2.745e-09
1.3652	4.610e-04	3.820e-09	3.841e-09	6.588e-12	6.624e-12
TOTALS:	2.208e+00	9.736e-06	9.817e-06	1.849e-08	1.865e-08

MicroShield v5.05 (5.05-00105)  
Stone & Webster

CNIC 016-01 (MY)

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File Ref:

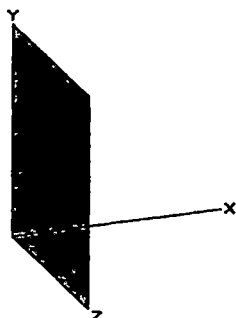
Date:

By:

Checked:

Page : 1  
DOS File: CC1.MS5  
Run Date: June 12, 2002  
Run Time: 11:00:09 AM  
Duration: 00:00:05

Case Title: AF 1 m<sup>2</sup>  
Description: Contaminated Concrete - MY nuclide mix  
Geometry: 4 - Rectangular Area - Vertical



#### Source Dimensions

Width 100.0 cm 3 ft 3.4 in  
Height 100.0 cm 3 ft 3.4 in

#### Dose Points

#	X	Y	Z
1	100 cm	50 cm	50 cm
	3 ft 3.4 in	1 ft 7.7 in	1 ft 7.7 in

#### Shields

Shield Name	Material	Density
Air Gap	Air	0.00122

#### Source Input

##### Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	$\mu\text{Ci/cm}^2$	Bq/cm <sup>2</sup>
Ba-137m	2.4800e-011	9.1760e-001	2.4800e-009	9.1760e-005
Co-57	1.3800e-014	5.1060e-004	1.3800e-012	5.1060e-008
Co-60	2.6300e-012	9.7310e-002	2.6300e-010	9.7310e-006
Cs-134	2.0500e-013	7.5850e-003	2.0500e-011	7.5850e-007
Cs-137	2.4800e-011	9.1760e-001	2.4800e-009	9.1760e-005
Fe-55	2.1700e-013	8.0290e-003	2.1700e-011	8.0290e-007
H-3	1.0600e-012	3.9220e-002	1.0600e-010	3.9220e-006
Ni-63	1.6000e-011	5.9200e-001	1.6000e-009	5.9200e-005
Sr-90	1.2600e-013	4.6620e-003	1.2600e-011	4.6620e-007
Y-90	1.2600e-013	4.6620e-003	1.2600e-011	4.6620e-007

#### Buildup

The material reference is : Air Gap

#### Integration Parameters

Z Direction 20  
Y Direction 20

#### Results

Energy MeV	Activity photons/sec	Fluence Rate		Exposure Rate	
		MeV/cm <sup>2</sup> /sec	MeV/cm <sup>2</sup> /sec	mR/hr	mR/hr
		No Buildup	With Buildup	No Buildup	With Buildup
0.0318	1.900e-02	3.996e-09	4.193e-09	3.329e-11	3.493e-11
0.0318	1.626e-05	3.421e-12	3.589e-12	2.849e-14	2.990e-14
0.0322	3.505e-02	7.465e-09	7.833e-09	6.008e-11	6.304e-11
0.0322	3.000e-05	6.390e-12	6.705e-12	5.142e-14	5.396e-14
0.0364	1.275e-02	3.088e-09	3.239e-09	1.754e-11	1.840e-11
0.0364	1.092e-05	2.643e-12	2.773e-12	1.502e-14	1.575e-14
0.1221	4.366e-04	3.596e-10	3.708e-10	5.639e-13	5.813e-13



Page : 2  
DOS File: CC1.MS5  
Run Date: June 12, 2002  
Run Time: 11:00:09 AM  
Duration: 00:00:05

C 91C 016 - 01 (M9)  
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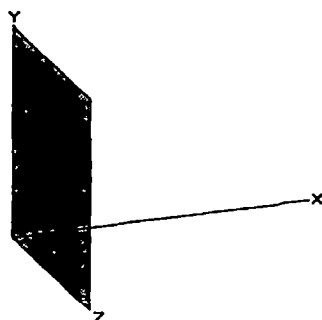
<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.1365	5.414e-05	4.989e-11	5.135e-11	8.022e-14	8.257e-14
0.2769	2.685e-06	5.039e-12	5.122e-12	9.452e-15	9.608e-15
0.4753	1.107e-04	3.577e-10	3.617e-10	7.019e-13	7.098e-13
0.536	1.464e-07	5.334e-13	5.389e-13	1.046e-15	1.057e-15
0.5632	6.356e-04	2.435e-09	2.459e-09	4.767e-12	4.814e-12
0.5693	1.170e-03	4.532e-09	4.576e-09	8.869e-12	8.956e-12
0.6047	7.403e-03	3.046e-08	3.074e-08	5.942e-11	5.998e-11
0.6616	8.257e-01	3.718e-06	3.751e-06	7.208e-09	7.271e-09
0.692	8.164e-07	3.846e-12	3.879e-12	7.428e-15	7.490e-15
0.6938	1.587e-05	7.497e-11	7.561e-11	1.448e-13	1.460e-13
0.7958	6.478e-03	3.512e-08	3.538e-08	6.683e-11	6.734e-11
0.8019	6.622e-04	3.617e-09	3.645e-09	6.878e-12	6.930e-12
1.0386	7.585e-05	5.372e-10	5.406e-10	9.837e-13	9.898e-13
1.1679	1.365e-04	1.088e-09	1.094e-09	1.946e-12	1.957e-12
1.1732	9.731e-02	7.789e-07	7.834e-07	1.392e-09	1.400e-09
1.3325	9.731e-02	8.851e-07	8.897e-07	1.536e-09	1.544e-09
1.3652	2.306e-04	2.149e-09	2.160e-09	3.706e-12	3.725e-12
TOTALS:	1.105e+00	5.478e-06	5.521e-06	1.040e-08	1.049e-08

MicroShield v5.05 (5.05-00105)  
Stone & Webster

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DOS File: CC\_5.MS5  
Run Date: June 12, 2002  
Run Time: 11:01:09 AM  
Duration: 00:00:05

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File Ref: \_\_\_\_\_  
Date: \_\_\_\_\_  
By: DR  
Checked: \_\_\_\_\_

Case Title: AF 0.5 m<sup>2</sup>  
Description: Contaminated Concrete - MY nuclide mix  
Geometry: 4 - Rectangular Area - Vertical



Source Dimensions  
Width 70.71 cm 2 ft 3.8 in  
Height 70.71 cm 2 ft 3.8 in

Dose Points  
# 1 X 100 cm Y 35.36 cm Z 35.36 cm  
3 ft 3.4 in 1 ft 1.9 in 1 ft 1.9 in

Shields  

Shield Name	Material	Density
Air Gap	Air	0.00122

Source Input  
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^2$	Bq/cm <sup>2</sup>
Ba-137m	1.2400e-011	4.5879e-001	2.4800e-009	9.1760e-005
Co-57	6.8999e-015	2.5530e-004	1.3800e-012	5.1060e-008
Co-60	1.3150e-012	4.8654e-002	2.6300e-010	9.7310e-006
Cs-134	1.0250e-013	3.7924e-003	2.0500e-011	7.5850e-007
Cs-137	1.2400e-011	4.5879e-001	2.4800e-009	9.1760e-005
Fe-55	1.0850e-013	4.0144e-003	2.1700e-011	8.0290e-007
H-3	5.2999e-013	1.9610e-002	1.0600e-010	3.9220e-006
Ni-63	7.9998e-012	2.9599e-001	1.6000e-009	5.9200e-005
Sr-90	6.2999e-014	2.3310e-003	1.2600e-011	4.6620e-007
Y-90	6.2999e-014	2.3310e-003	1.2600e-011	4.6620e-007

Buildup  
The material reference is : Air Gap

Integration Parameters  
Z Direction 20  
Y Direction 20

Energy MeV	Activity photons/sec	Results			
		Fluence Rate MeV/cm <sup>2</sup> /sec No Buildup	Fluence Rate MeV/cm <sup>2</sup> /sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	9.498e-03	2.142e-09	2.245e-09	1.785e-11	1.870e-11
0.0318	8.130e-06	1.834e-12	1.921e-12	1.528e-14	1.600e-14
0.0322	1.752e-02	4.002e-09	4.193e-09	3.221e-11	3.374e-11
0.0322	1.500e-05	3.426e-12	3.589e-12	2.757e-14	2.888e-14
0.0364	6.377e-03	1.655e-09	1.734e-09	9.403e-12	9.850e-12
0.0364	5.459e-06	1.417e-12	1.484e-12	8.049e-15	8.431e-15
0.1221	2.183e-04	1.927e-10	1.984e-10	3.021e-13	3.111e-13

Page : 2  
 DOS File: CC\_5.MS5  
 Run Date: June 12, 2002  
 Run Time: 11:01:09 AM  
 Duration: 00:00:05

Calc 016-01 (M1)  
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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.1365	2.707e-05	2.673e-11	2.748e-11	4.298e-14	4.419e-14
0.2769	1.343e-06	2.699e-12	2.742e-12	5.063e-15	5.144e-15
0.4753	5.537e-05	1.916e-10	1.937e-10	3.760e-13	3.800e-13
0.536	7.318e-08	2.857e-13	2.885e-13	5.603e-16	5.659e-16
0.5632	3.178e-04	1.304e-09	1.317e-09	2.553e-12	2.578e-12
0.5693	5.852e-04	2.427e-09	2.450e-09	4.751e-12	4.796e-12
0.6047	3.701e-03	1.631e-08	1.646e-08	3.183e-11	3.211e-11
0.6616	4.128e-01	1.992e-06	2.008e-06	3.861e-09	3.893e-09
0.692	4.082e-07	2.060e-12	2.077e-12	3.978e-15	4.011e-15
0.6938	7.936e-06	4.016e-11	4.048e-11	7.753e-14	7.816e-14
0.7958	3.239e-03	1.881e-08	1.895e-08	3.580e-11	3.606e-11
0.8019	3.311e-04	1.937e-09	1.952e-09	3.684e-12	3.711e-12
1.0386	3.792e-05	2.877e-10	2.895e-10	5.268e-13	5.300e-13
1.1679	6.826e-05	5.826e-10	5.859e-10	1.042e-12	1.048e-12
1.1732	4.865e-02	4.172e-07	4.195e-07	7.455e-10	7.496e-10
1.3325	4.865e-02	4.740e-07	4.764e-07	8.224e-10	8.266e-10
1.3652	1.153e-04	1.151e-09	1.157e-09	1.985e-12	1.995e-12
TOTALS:	5.523e-01	2.934e-06	2.956e-06	5.571e-09	5.616e-09

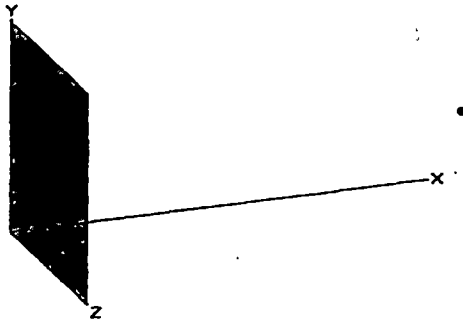
MicroShield v5.05 (5.05-00105)  
Stone & Webster

Case 016-01 (M)  
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DOS File: CC\_25.MS5  
Run Date: June 12, 2002  
Run Time: 11:01:46 AM  
Duration: 00:00:05

File Ref: \_\_\_\_\_  
Date: \_\_\_\_\_  
By: DR  
Checked: \_\_\_\_\_

Case Title: AF 0.25 m<sup>2</sup>  
Description: Contaminated Concrete - MY nuclide mix  
Geometry: 4 - Rectangular Area - Vertical



## Source Dimensions

Width 50.0 cm 1 ft 7.7 in  
Height 50.0 cm 1 ft 7.7 in

## Dose Points

#	X	Y	Z
1	100 cm	25 cm	25 cm
	3 ft 3.4 in	9.8 in	9.8 in

## Shields

Shield Name	Material	Density
Air Gap	Air	0.00122

## Source Input

## Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^2$	Bq/cm <sup>2</sup>
Ba-137m	6.2000e-012	2.2940e-001	2.4800e-009	9.1760e-005
Co-57	3.4500e-015	1.2765e-004	1.3800e-012	5.1060e-008
Co-60	6.5750e-013	2.4328e-002	2.6300e-010	9.7310e-006
Cs-134	5.1250e-014	1.8963e-003	2.0500e-011	7.5850e-007
Cs-137	6.2000e-012	2.2940e-001	2.4800e-009	9.1760e-005
Fe-55	5.4250e-014	2.0073e-003	2.1700e-011	8.0290e-007
H-3	2.6500e-013	9.8050e-003	1.0600e-010	3.9220e-006
Ni-63	4.0000e-012	1.4800e-001	1.6000e-009	5.9200e-005
Sr-90	3.1500e-014	1.1655e-003	1.2600e-011	4.6620e-007
Y-90	3.1500e-014	1.1655e-003	1.2600e-011	4.6620e-007

## Buildup

The material reference is : Air Gap

## Integration Parameters

Z Direction 20  
Y Direction 20

## Results

Energy MeV	Activity photons/sec	Fluence Rate		Exposure Rate	
		MeV/cm <sup>2</sup> /sec No Buildup	MeV/cm <sup>2</sup> /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.0318	4.749e-03	1.113e-09	1.165e-09	9.271e-12	9.704e-12
0.0318	4.065e-06	9.527e-13	9.972e-13	7.935e-15	8.307e-15
0.0322	8.762e-03	2.079e-09	2.176e-09	1.673e-11	1.751e-11
0.0322	7.500e-06	1.780e-12	1.863e-12	1.432e-14	1.499e-14
0.0364	3.189e-03	8.597e-10	8.997e-10	4.884e-12	5.112e-12
0.0364	2.729e-06	7.359e-13	7.702e-13	4.181e-15	4.376e-15
0.1221	1.092e-04	1.001e-10	1.030e-10	1.569e-13	1.615e-13

Page : 2  
 DOS File: CC\_25.MS5  
 Run Date: June 12, 2002  
 Run Time: 11:01:46 AM  
 Duration: 00:00:05

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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm<sup>2</sup>/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.1365	1.353e-05	1.388e-11	1.427e-11	2.232e-14	2.294e-14
0.2769	6.713e-07	1.402e-12	1.424e-12	2.629e-15	2.670e-15
0.4753	2.769e-05	9.949e-11	1.006e-10	1.952e-13	1.973e-13
0.536	3.659e-08	1.484e-13	1.498e-13	2.909e-16	2.938e-16
0.5632	1.589e-04	6.772e-10	6.835e-10	1.326e-12	1.338e-12
0.5693	2.926e-04	1.260e-09	1.272e-09	2.467e-12	2.490e-12
0.6047	1.851e-03	8.470e-09	8.545e-09	1.653e-11	1.667e-11
0.6616	2.064e-01	1.034e-06	1.043e-06	2.005e-09	2.021e-09
0.692	2.041e-07	1.070e-12	1.078e-12	2.066e-15	2.082e-15
0.6938	3.968e-06	2.085e-11	2.102e-11	4.026e-14	4.058e-14
0.7958	1.619e-03	9.765e-09	9.836e-09	1.859e-11	1.872e-11
0.8019	1.655e-04	1.006e-09	1.013e-09	1.913e-12	1.926e-12
1.0386	1.896e-05	1.494e-10	1.503e-10	2.735e-13	2.752e-13
1.1679	3.413e-05	3.025e-10	3.042e-10	5.411e-13	5.441e-13
1.1732	2.433e-02	2.166e-07	2.178e-07	3.871e-10	3.892e-10
1.3325	2.433e-02	2.461e-07	2.473e-07	4.270e-10	4.291e-10
1.3652	5.765e-05	5.975e-10	6.005e-10	1.030e-12	1.035e-12
TOTALS:	2.761e-01	1.523e-06	1.535e-06	2.893e-09	2.915e-09

**MYAPC License Termination Plan  
Revision 3  
October 15, 2002**

**Attachment 6-16  
Forebay Sediment Dose Assessment  
(Has been replaced by Attachment 2H)**

**MYAPC License Termination Plan**  
**Revision 4**  
**February 28, 2005**

**Attachment 6-17**  
**Unitized Dose Factors for Activated Rebar**

- Deleted -

**MYAPC License Termination Plan**  
**Revision 3**  
**October 15, 2002**

**Attachment 6-18**  
**NRC Screening Levels for Contaminated Basement and Special Areas**



Contaminated Basement Surfaces DCGL For Building Occupancy NRC Screening Levels				
Nuclide	Fractions <i>nf</i>	Screening Level dpm/100 cm <sup>2</sup>	Beta Fraction	<i>nf</i> /Screening Level
Sr-90	2.80E-03	8.71E+03	2.80E-03	3.22E-07
Cs-134	4.55E-03	1.27E+04	4.55E-03	3.58E-07
Cs-137	5.50E-01	2.80E+04	5.50E-01	1.97E-05
Co-60	5.84E-02	7.05E+03	5.84E-02	8.29E-06
Co-57	3.06E-04	2.11E+05		1.45E-09
Fe-55	4.81E-03	4.50E+06		1.07E-09
H-3	2.36E-02	1.24E+08		1.90E-10
Ni-63	3.55E-01	1.82E+06		1.95E-07
		sum	6.16E-01	2.88E-05

2.14E+04 dpm/100 cm <sup>2</sup> gross beta
---

**NRC Screening Level Special Area Surfaces\***

EC-011-01		Pipe Tunnel		TRU values use RF <sub>0</sub> 9.6E-07 m <sup>-1</sup>	
2004		& O/A Trench		Screening	
2004		2004		Level	
Mean nf	Nuclide	Mean nf	dpm/100 cm <sup>2</sup>	Beta Fraction	nf/Screening Level
4.028E-04	Mn-54	4.028E-04	3.15E+04		1.279E-08
2.235E-02	Fe-55	2.235E-02	4.50E+06		4.967E-09
3.639E-01	Co-60	3.639E-01	7.05E+03	3.639E-01	5.162E-05
3.024E-01	Ni-63	3.024E-01	1.82E+06		1.661E-07
6.874E-03	Sr-90	6.874E-03	8.71E+03	6.874E-03	7.892E-07
4.523E-03	Sb-125	4.523E-03	4.43E+04	4.523E-03	1.021E-07
2.815E-03	Cs-134	2.815E-03	1.27E+04	2.815E-03	2.216E-07
2.890E-01	Cs-137	2.890E-01	2.80E+04	2.890E-01	1.032E-05
1.165E-04	Pu-238	1.165E-04	4.24E+02		2.750E-07
8.752E-05	Pu-239	8.752E-05	3.85E+02		2.272E-07
8.750E-05	Pu-240	8.750E-05	3.85E+02		2.272E-07
6.705E-03	Pu-241	6.705E-03	1.97E+04		3.406E-07
5.929E-04	Am-241	5.929E-04	3.73E+02		1.591E-06
4.649E-05	Cm-243	4.649E-05	5.43E+02		8.555E-08
4.454E-05	Cm-244	4.454E-05	6.79E+02		6.556E-08
detectable beta fraction ==>					6.672E-01
sum of nf/screening level ==>					6.605E-05
sum beta fraction divided by sum of nf divided by screening level ==>					1.010E+04
					detectable beta in dpm/100 cm <sup>2</sup>

\*Using 9.6E-07 resuspension factor for TRU's (from NUREG-1720)

**MYAPC License Termination Plan**  
**Revision 3**  
**October 15, 2002**

**Attachment 6-19**  
**Special Areas Unitized Dose Factors**

**Attachment 6-19  
Special Areas Unitized Dose Factors**

**Key Parameters**

Porosity	0.30	Fill Volume	2460.0	m <sup>3</sup>	Annual Total Well Water Vol	738.0	m <sup>3</sup>	
Bulk Density	1.50	g/cm <sup>3</sup>	Surface Area/Open Volume	1.70	m <sup>2</sup> /m <sup>3</sup>	Irrigation Rate	0.274	L/m <sup>2</sup> -d
Yearly Drinking Water	478.0	L/yr	Concrete Volume	4.18	m <sup>3</sup>	Surface Soil Depth	0.15	m
Wall Surface Area	4182.0	m <sup>2</sup>	Concrete Density	2.20	g/cm <sup>3</sup>			

DOSE CALCULATION FACTORS				Source Term		Kd		WATER, FILL, CONCRETE CONCENTRATION				CONTAMINATED CONCRETE ANNUAL DOSE				
Nuclide	NUREG-1727 mrem/y per pCi/g	FGR 11 mrem/pCi	Microshield mrem/y per pCi/g	Inventory dpm/100 cm2	Inventory pCi	Kd Fill cm3/gm	Kd Concrete cm3/gm	Adsorption Factor	Water pCi/L	Fill pCi/g	Concrete pCi/g	Nuclide	Drinking Water Dose mrem/y	Irrigation Dose mrem/y	Direct Dose mrem/y	Total Dose mrem/y
Sr-90	1.47E+01	1.42E-04	0.00E+00	1.00E+00	1.88E+05	6.02E+01	1.00E+00	3.01E+02	8.46E-04	5.09E-05	8.46E-07	Sr-90	5.74E-05	5.53E-06	0.00E+00	6.29E-05
Sb-125	9.77E-01	2.81E-08	3.83E-06	1.00E+00	1.88E+05	4.50E+01	0.00E+00	2.26E+02	1.13E-03	5.08E-05	0.00E+00	Sb-125	1.52E-06	4.90E-07	1.95E-10	2.01E-06
Cs-134	4.39E+00	7.33E-05	6.09E-05	1.00E+00	1.88E+05	7.91E+01	3.00E+00	3.98E+02	6.44E-04	5.09E-05	1.93E-06	Cs-134	2.26E-05	1.26E-06	3.10E-09	2.38E-05
Cs-137	2.27E+00	5.00E-05	1.20E-05	1.00E+00	1.88E+05	7.91E+01	3.00E+00	3.98E+02	6.44E-04	5.09E-05	1.93E-06	Cs-137	1.54E-05	6.49E-07	6.11E-10	1.60E-05
Pu-238	1.00E+01	3.20E-03	2.45E-25	1.00E+00	1.88E+05	5.50E+02	5.00E+03	2.81E+03	9.07E-05	4.99E-05	4.54E-04	Pu-238	1.39E-04	4.03E-07	1.22E-29	1.39E-04
Pu-239	1.09E+01	3.54E-03	6.10E-15	1.00E+00	1.88E+05	5.50E+02	5.00E+03	2.81E+03	9.07E-05	4.99E-05	4.54E-04	Pu-239	1.54E-04	4.40E-07	3.04E-19	1.54E-04
Pu-240	1.09E+01	3.54E-03	7.52E-26	1.00E+00	1.88E+05	5.50E+02	5.00E+03	2.81E+03	9.07E-05	4.99E-05	4.54E-04	Pu-240	1.54E-04	4.40E-07	3.75E-30	1.54E-04
Pu-241	3.47E-01	6.85E-05	0.00E+00	1.00E+00	1.88E+05	5.50E+02	5.00E+03	2.81E+03	9.07E-05	4.99E-05	4.54E-04	Pu-241	2.97E-06	1.40E-08	0.00E+00	2.98E-06
Am-241	1.19E+01	3.64E-03	1.65E-19	1.00E+00	1.88E+05	1.90E+03	5.00E+03	9.55E+03	2.67E-05	5.07E-05	1.33E-04	Am-241	4.64E-05	1.41E-07	8.39E-24	4.66E-05
Cm-243	7.81E+00	2.51E-03	1.27E-08	1.00E+00	1.88E+05	4.00E+03	5.00E+03	2.00E+04	1.27E-05	5.09E-05	6.36E-05	Cm-243	1.53E-05	4.42E-08	6.46E-13	1.53E-05
Cm-244	6.00E+00	2.02E-03	9.81E-25	1.00E+00	1.88E+05	4.00E+03	5.00E+03	2.00E+04	1.27E-05	5.09E-05	6.36E-05	Cm-244	1.23E-05	3.39E-08	4.99E-29	1.23E-05
Co-60	6.58E+00	2.69E-05	6.30E-04	1.00E+00	1.88E+05	1.28E+02	1.00E+02	6.40E+02	3.98E-04	5.09E-05	3.98E-05	Co-60	5.12E-06	1.16E-06	3.20E-08	6.32E-06
Co-57	1.67E-01	1.18E-06	2.80E-08	1.00E+00	1.88E+05	1.28E+02	1.00E+02	6.40E+02	3.98E-04	5.09E-05	3.98E-05	Co-57	2.25E-07	2.96E-08	1.42E-12	2.54E-07
Mn-54	1.67E+00	2.77E-06	4.40E-05	1.00E+00	1.88E+05	5.00E+01	0.00E+00	2.51E+02	1.02E-03	5.08E-05	0.00E+00	Mn-54	1.35E-06	7.55E-07	2.24E-09	2.10E-06
Fe-55	2.50E-03	6.07E-07	0.00E+00	1.00E+00	1.88E+05	2.50E+01	1.00E+02	1.27E+02	2.01E-03	5.01E-05	2.01E-04	Fe-55	5.82E-07	2.23E-09	0.00E+00	5.84E-07
H-3	2.27E-01	6.40E-08	0.00E+00	1.00E+00	1.88E+05	0.00E+00	0.00E+00	1.00E+00	2.55E-01	0.00E+00	0.00E+00	H-3	7.80E-06	2.57E-05	0.00E+00	3.35E-05
Ni-63	1.19E-02	5.77E-07	0.00E+00	1.00E+00	1.88E+05	1.28E+02	1.00E+02	6.40E+02	3.98E-04	5.09E-05	3.98E-05	Ni-63	1.10E-07	2.11E-09	0.00E+00	1.12E-07

**MYAPC License Termination Plan**  
**Revision 4**  
**February 28, 2005**

**Attachment 6-20**  
**Dose Model Input Parameters**

## Dose Model Input Parameters

Attachment 6-20 |

Item A.8 of the Maine Yankee License Termination Plan Settlement Agreement states the following:

“Maine Yankee will provide the State with a table or tables, listing all parameters used in the calculations, showing symbols, dimensional units, numerical values and quantitative distributional information. The basis of the numerical values shall be indicated, even if they are defaults or unsupported assumptions. Maine Yankee will include this information in a subsequent revision to the License Termination Plan.”

Section 6 of the LTP provides dose models and methodologies for determining the dose contributions from the listed contaminated materials. The parameters identified in this list are consistent with those used as the basis for LTP Revision 3, dated October 15, 2003. The Engineering Calculations used to compile this list are identified following the list.

Parameter Designation (Symbol)	Parameter Description	Dimensional Units	Numerical Value	Quantitative Distributional Information	Basis
<b><u>I. Basement Fill Model</u></b>					
<b>A. Annual Domestic Water Usage</b>					
V <sub>dr</sub>	Volume of Water Removed from the Aquifer Per Year for Domestic Uses (Behavioral) for Maine	Liters/yr per capita	124,422	Constant	NUREG-5512 Vol. 3, Section 6.2.8, Table 6.19, pg 6-38. USGS water usage data.
P <sub>D</sub>	Population Density for land	Person/m <sup>2</sup>	0.0004	Constant	NUREG-1727 App D., Section 1.2, Table D2, pg. D10 NUREG-1496, Vol. 2, App B, Table A.1, Note f., pg. B.A-2
A	Size of Resident Farm Property	m <sup>2</sup>	10,000	Constant	Size of Restricted Area
<b>B. Annual Irrigation Water Usage and Dose</b>					
IR	Irrigation Rate	cm/y	10	Constant	USDA/NRCS see MYLTP Attachment 6-4
IR	Irrigation Rate	L/m <sup>2</sup> /d	0.274	Constant	Same as above (converted units)

### Dose Model Input Parameters

Attachment 6-20

Parameter Designation (Symbol)	Parameter Description	Dimensional Units	Numerical Value	Quantitative Distributional Information	Basis
$A_r$	Cultivated Area	m <sup>2</sup>	2400	Constant	NUREG-1727, App C, Section 2.3.2, pg. C12
H <sub>l</sub>	Thickness of surface-soil layer	m	0.15	Constant	NUREG-5512, Vol. 1, Table 6.23 pg. 6.42
Soil <sub>SV</sub>	Surface Soil Screening Values	pCi/g	Per Nuclide	Constant	NUREG-1727, App C, Section 2.3.3, Table C2.3, pgs. C16-C17
$\bar{\alpha}_{SOIL}$	Soil Density	g/cm <sup>3</sup>	1.6	Constant	MYLTP Attachment 6-2
<b>C. Drinking Water Dose</b>					
U <sub>w</sub>	Annual Drinking Water Volume	L/y	478	Constant	NRC DandD Version 1
DCF	Dose Conversion Factors	mrem/pCi	Per Nuclide	Constant	Federal Guidance Report No. 11
<b>D. Direct Dose</b>					
H <sub>soil backfill cover</sub>	Soil Cover over filled basement	ft.	3	Constant	Backfill over demolition above 3ft. below grade
TX	Exposure period: outdoors	hrs.	964	Constant	Based upon Occupancy Rate: 0.1101 from NRC DandD, Ver. 1 NUREG/CR-5512 Vol. 3, Section 6.2.3 and Table 6.87, pg. 6-126
H <sub>fill</sub>	Depth of Fill	m	5.8	Constant	Deepest Basement: Containment
A	Size of Resident Farm	m <sup>2</sup>	10,000	Constant	Size of Restricted Area

**Dose Model Input Parameters**

Attachment 6-20 |

<b>Parameter Designation (Symbol)</b>	<b>Parameter Description</b>	<b>Dimensional Units</b>	<b>Numerical Value</b>	<b>Quantitative Distributional Information</b>	<b>Basis</b>
<b>E. Model Volume and Surface Area Calculation</b>					
$N_{\text{fill}}$	Porosity of Basement Fill	Unitless	0.3	Constant	Conservatively selected based upon NUREG-5512, Vol. 3, Section 6.4.3, Table 6.41, pg. 6-64
$V_{\text{Containment}}$	Open Air Volume of Containment Basement	$\text{m}^3$	8217	Constant	MY Eng. Calc EC 001-00
$V_{\text{CSB}}$	Open Air Volume of Spray Building Basement	$\text{m}^3$	1584	Constant	MY Eng. Calc EC 001-00
$V_{\text{PAB}}$	Open Air Volume of Primary Auxiliary Building Basement	$\text{m}^3$	1136	Constant	MY Eng. Calc EC 001-00
$V_{\text{FB}}$	Open Air Volume of Fuel Building Basement	$\text{m}^3$	837	Constant	MY Eng. Calc EC 001-00
$SA_{\text{Containment}}$	Surface Area of Containment Basement	$\text{m}^2$	3775	Constant	MY Eng. Calc EC 001-00
$SA_{\text{CSB}}$	Surface Area of Spray Building Basement	$\text{m}^2$	1637	Constant	MY Eng. Calc EC 001-00
$SA_{\text{PAB}}$	Surface Area of Primary Auxiliary Building Basement	$\text{m}^2$	1883	Constant	MY Eng. Calc EC 001-00
$SA_{\text{FB}}$	Surface Area of Fuel Building Basement	$\text{m}^2$	409	Constant	MY Eng. Calc EC 001-00



### Dose Model Input Parameters

Attachment 6-20

Parameter Designation (Symbol)	Parameter Description	Dimensional Units	Numerical Value	Quantitative Distributional Information	Basis
<b>F. Mass Balance Soil Term</b>					
$\bar{\alpha}_{\text{FILL}}$	Basement Fill Density	g/cm <sup>3</sup>	1.5	Constant	MYLTP Attachment 6-2
$V_F$	Volume of Fill available for radionuclide re-adsorption	m <sup>3</sup>	2460	Constant	Calculated as Model Volume
$K_{d-\text{fill-H-3}}$	Fill Distribution Coefficient for H-3	cm <sup>3</sup> /g	0	Constant	Conservatively Selected
$K_{d-\text{fill-Fe-55}}$	Fill Distribution Coefficient for Fe-55	cm <sup>3</sup> /g	25	Constant	Baes-1984, Table 2.13
$K_{d-\text{fill-Ni-63}}$	Fill Distribution Coefficient for Ni-63	cm <sup>3</sup> /g	128	Constant	MYLTP Attachment 6-2
$K_{d-\text{fill-Mn-54}}$	Fill Distribution Coefficient for Mn-54	cm <sup>3</sup> /g	50	Constant	NUREG-5512, Vol. 3, Table 6.84, pg. 6-118; Sheppard-1990, Table A-1
$K_{d-\text{fill-Co-57}}$	Fill Distribution Coefficient for Co-57	cm <sup>3</sup> /g	128	Constant	MYLTP Attachment 6- 2
$K_{d-\text{fill-Co-60}}$	Fill Distribution Coefficient for Co-60	cm <sup>3</sup> /g	128	Constant	MYLTP Attachment 6-2
$K_{d-\text{fill-Cs-134}}$	Fill Distribution Coefficient for Cs-134	cm <sup>3</sup> /g	79	Constant	MYLTP Attachment 6-2
$K_{d-\text{fill-Cs-137}}$	Fill Distribution Coefficient for Cs-137	cm <sup>3</sup> /g	79	Constant	MYLTP Attachment 6-2
$K_{d-\text{fill-Sr-90}}$	Fill Distribution Coefficient for Sr-90	cm <sup>3</sup> /g	60	Constant	MYLTP Attachment 6-2
$K_{d-\text{fill-Sb-125}}$	Fill Distribution Coefficient for Sb-125	cm <sup>3</sup> /g	45	Constant	NUREG-5512, Vol. 3, Table 6.84, pg. 6-118; Sheppard-1990, Table A-1

**Dose Model Input Parameters**

Attachment 6-20

<b>Parameter Designation (Symbol)</b>	<b>Parameter Description</b>	<b>Dimensional Units</b>	<b>Numerical Value</b>	<b>Quantitative Distributional Information</b>	<b>Basis</b>
K <sub>d-fill-Pu-238</sub>	Fill Distribution Coefficient for Pu-238	cm <sup>3</sup> /g	550	Constant	NUREG-5512, Vol. 3, Table 6.84, pg. 6-118; Sheppard-1990, Table A-1
K <sub>d-fill-Pu-239/240</sub>	Fill Distribution Coefficient for Pu-239/240	cm <sup>3</sup> /g	550	Constant	NUREG-5512, Vol. 3, Table 6.84, pg. 6-118; Sheppard-1990, Table A-1
K <sub>d-fill-Pu-241</sub>	Fill Distribution Coefficient for Pu-241	cm <sup>3</sup> /g	550	Constant	NUREG-5512, Vol. 3, Table 6.84, pg. 6-118; Sheppard-1990, Table A-1
K <sub>d-fill-Am-241</sub>	Fill Distribution Coefficient for Am-241	cm <sup>3</sup> /g	1900	Constant	NUREG-5512, Vol. 3, Table 6.84, pg. 6-118; Sheppard-1990, Table A-1
K <sub>d-fill-Cm243/244</sub>	Fill Distribution Coefficient for Cm243/244	cm <sup>3</sup> /g	4000	Constant	NUREG-5512, Vol. 3, Table 6.84, pg. 6-118; Sheppard-1990, Table A-1
K <sub>d-fill-C-14</sub>	Fill Distribution Coefficient for C-14	cm <sup>3</sup> /g	5	Constant	Sheppard-1990, Table A-1
K <sub>d-fill-Eu-152</sub>	Fill Distribution Coefficient for Eu-152	cm <sup>3</sup> /g	400	Constant	Onishi-1981, Table 8.35
K <sub>d-fill-Eu-154</sub>	Fill Distribution Coefficient for Eu-154	cm <sup>3</sup> /g	400	Constant	Onishi-1981, Table 8.35

### Dose Model Input Parameters

Attachment 6-20

Parameter Designation (Symbol)	Parameter Description	Dimensional Units	Numerical Value	Quantitative Distributional Information	Basis
<b>G. Mass Balance Concrete Term</b>					
$\bar{\alpha}_{\text{CONCRETE}}$	Basement Concrete Density	g/cm <sup>3</sup>	2.2	Constant	MYLTP Attachment 6-5
$H_C$	Depth of Concrete Available for radionuclide re-adsorption	mm	1	Constant	MY Eng. Calc EC 010-01
$V_C$	Volume of Concrete Available for radionuclide re-adsorption	m <sup>3</sup>	4.18	Constant	Calculated: $H_C$ * Model Surface Area
$K_{d-\text{conc-H-3}}$	Concrete Distribution Coefficient for H-3	cm <sup>3</sup> /g	0	Constant	Conservatively Selected
$K_{d-\text{conc-Fe-55}}$	Concrete Distribution Coefficient for Fe-55	cm <sup>3</sup> /g	100	Constant	Krupka-1998 Table 5.1
$K_{d-\text{conc-Ni-63}}$	Concrete Distribution Coefficient for Ni-63	cm <sup>3</sup> /g	100	Constant	Krupka-1998 Table 5.1
$K_{d-\text{conc-Co-57}}$	Concrete Distribution Coefficient for Co-57	cm <sup>3</sup> /g	100	Constant	Krupka-1998 Table 5.1
$K_{d-\text{conc-Co-60}}$	Concrete Distribution Coefficient for Co-60	cm <sup>3</sup> /g	100	Constant	Krupka-1998 Table 5.1
$K_{d-\text{conc-Cs-134}}$	Concrete Distribution Coefficient for Cs-134	cm <sup>3</sup> /g	3	Constant	MYLTP Attachment 6-3
$K_{d-\text{conc-Cs-137}}$	Concrete Distribution Coefficient for Cs-137	cm <sup>3</sup> /g	3	Constant	MYLTP Attachment 6-3
$K_{d-\text{conc-Sr-90}}$	Concrete Distribution Coefficient for Sr-90	cm <sup>3</sup> /g	1.0	Constant	MYLTP Attachment 6-3

### Dose Model Input Parameters

Attachment 6-20

Parameter Designation (Symbol)	Parameter Description	Dimensional Units	Numerical Value	Quantitative Distributional Information	Basis
$K_{d\text{-conc-Pu-238}}$	Concrete Distribution Coefficient for Pu-238	$\text{cm}^3/\text{g}$	5000	Constant	Krupka-1998 Table 5.1
$K_{d\text{-conc-Pu-239/240}}$	Concrete Distribution Coefficient for Pu-239/240	$\text{cm}^3/\text{g}$	5000	Constant	Krupka-1998 Table 5.1
$K_{d\text{-conc-Pu-241}}$	Concrete Distribution Coefficient for Pu-241	$\text{cm}^3/\text{g}$	5000	Constant	Krupka-1998 Table 5.1
$K_{d\text{-conc-Am-241}}$	Concrete Distribution Coefficient for Am-241	$\text{cm}^3/\text{g}$	5000	Constant	Krupka-1998 Table 5.1
$K_{d\text{-conc-Cm243/244}}$	Concrete Distribution Coefficient for Cm243/244	$\text{cm}^3/\text{g}$	5000	Constant	Krupka-1998 Table 5.1
<b>H. Total Basement Fill Dose</b>					
$NF_{CC}$	Contaminated Concrete Nuclide Fraction - Balance of Plant	Unitless	Per Nuclide	Constant	MYLTP Section 2.5.3, Table 2-7, pg. 2-54
$NF_{SC}$	Contaminated Concrete Nuclide Fraction - Special Areas	Unitless	Per Nuclide	Constant	MYLTP Section 2.5.3, Table 2-8, pg. 2-55
$NF_{AC}$	Activated Concrete Nuclide Fraction	Unitless	Per Nuclide	Constant	MYLTP Section 2.5.3, Table 2-9, pg. 2-57
$NF_{AR}$	Activated Rebar Nuclide Fraction	Unitless	Per Nuclide	Constant	MYLTP Section 2.5.3, Table 2-9, pg. 2-57
$I_{\text{Activated}}$	Total Activated Inventory	pCi	3.30E+08	Constant	MYLTP Attachment 6-6
$C_{AR/AC}$	Concentration of Activated Rebar to Activated Concrete	pCi/g	1.9	Constant	MY Eng. Calc. EC-022-00, pg. 13 (51,670/27,380) * 1 pCi/g

### Dose Model Input Parameters

Attachment 6-20

Parameter Designation (Symbol)	Parameter Description	Dimensional Units	Numerical Value	Quantitative Distributional Information	Basis
$I_{EP-BOP}$	Total Embedded Pipe Inventory for Balance of Plant Pipe	pCi	5754.5	Constant	MYLTP Section 6.6.3 & Attachment 6-7
$I_{EP-Spray}$	Total Embedded Pipe Inventory for Containment Spray Pipe	pCi	1191.7	Constant	MYLTP Section 6.6.3 & Attachment 6-7
<b>II. Surface Soil</b>					
H1	Thickness of surface-soil layer	m	0.15	Constant	NUREG-5512, Vol. 1, Table 6.23 pg. 6.42
Soil <sub>SV</sub>	Surface Soil Screening Values	pCi/g	Per Nuclide	Constant	NUREG-1727, App C, Section 2.3.3, Table C2.3, pgs. C16-C17
Cond <sub>Sat Hydrol</sub>	Saturated Vertical Hydraulic Conductivity - Minimum	cm/sec	0.001	Constant	Adams or Hinckley USDA Soil Series, MYLTP Section 6.6.4
NF <sub>Soil</sub>	Contaminated Soil Nuclide Fraction - Special Areas	Unitless	Per Nuclide	Constant	MYLTP Section 2.5.3, Table 2-11, pg. 2-59
<b>III. Deep Soil</b>					
<b>A. Direct Dose Microshield Input Parameters</b>					
H <sub>Surface Soil Cover</sub>	Depth of Surface Soil Cover	cm	15	Constant	Surface soil dose treated separately
H <sub>Deep Soil</sub>	Depth of Deep Soil	m	2.85	Constant	Nominal depth of soil to bedrock in restricted area
A <sub>DS</sub>	Area of Deep Soil Contamination	m <sup>2</sup>	10,000	Constant	Equivalent to restricted area
TI	Indoor Occupancy Time	y	0.6571	Constant	NRC DandD Version 1D

### Dose Model Input Parameters

Attachment 6-20

Parameter Designation (Symbol)	Parameter Description	Dimensional Units	Numerical Value	Quantitative Distributional Information	Basis
TX	Outdoor Occupancy Time	y	0.1101	Constant	NRC DandD Version 1
SFO	External Radiation Shielding Factor	unitless	0.5512	Constant	NRC DandD Version 1 (Used in Microshield analysis)
$\rho_{\text{SOIL}}$	Soil Density	g/cm <sup>3</sup>	1.6	Constant	MYLTP Attachment 6-2
<b>B. Drinking &amp; Irrigation Water Dose (See Attached Table of RESRAD Input Parameters)</b>					
See Below	See Below	See Below	See Below	See Below	NUREG/CR-5512 unless otherwise noted
<b>IV. Buried Pipe</b>					
<b>A. Direct Dose Microshield Input Parameters</b>					
H <sub>BP</sub> Backfill Cover	Depth of Buried Pipe Backfill Cover	ft	3	Constant	Backfill over demolition above 3ft. below grade
SA <sub>BP</sub>	Total Buried Pipe Surface Area	m <sup>2</sup>	1302	Constant	MYLTP Attachment 6-10
VBP	Total Buried Pipe Volume	m <sup>3</sup>	141.8	Constant	MYLTP Attachment 6-10
H <sub>Deep Soil</sub>	Depth of Consolidated Buried Pipe Source Term	m	1	Constant	MYLTP Attachment 6-10 Assumption
A <sub>DS</sub>	Area of Consolidated Buried Pipe Source Term	m <sup>2</sup>	141.8	Constant	Encompasses restricted area
TI	Indoor Occupancy Time	y	0.6571	Constant	NRC DandD Version 1
TX	Outdoor Occupancy Time	y	0.1101	Constant	NRC DandD Version 1

### Dose Model Input Parameters

Attachment 6-20

Parameter Designation (Symbol)	Parameter Description	Dimensional Units	Numerical Value	Quantitative Distributional Information	Basis
SFO	External Radiation Shielding Factor	unitless	0.5512	Constant	NRC DandD Version 1 (Used in Microshield analysis)
$\bar{a}_{\text{SOIL}}$	Soil Density	g/cm <sup>3</sup>	1.6	Constant	MYLTP Attachment 6-2
<b>B. Drinking &amp; Irrigation Water Dose</b> (See Attached Table of RESRAD Input Parameters)					
See Below	See Below	See Below	See Below	See Below	NUREG/CR-5512 unless otherwise noted
<b>V. Groundwater and Surface Water</b>					
$U_w$	Annual Drinking Water Volume	L/y	478	Constant	NRC DandD Version 1
$DCF_{\text{H-3}}$	Dose Conversion Factor for H-3	mrem/pCi	6.4E-08	Constant	Federal Guidance Report No. 11
$Ba_{\text{jf}}$	Fish Bioaccumulation Factor for H-3	pCi/kg wet weight per pCi/L	1	Constant	NUREG/CR-5512, Vol. 3, Section 6.4.1, Table 6-30, Part 3, pg. 6-54 Reg Guide 1.109
$U_f$	Fish Consumption	kg/y	20.6	Constant	NRC DandD Version 1 NUREG/CR-5512 Vol. 3, Section 6.2.9 and Table 6.87, pg. 6-127
<b>VI. Standing Buildings</b>					
$NF_{\text{CC}}$	Contaminated Concrete Nuclide Fraction - Balance of Plant	Unitless	Per Nuclide	Constant	MYLTP Section 2.5.3, Table 2-7, pg. 2-54
$\text{Soil}_{\text{sv}}$	Building Surface Screening Values	pCi/g	Per Nuclide	Constant	NUREG-1727, App C, Section 2.3.3, Table C2.2, pgs. C15

### Dose Model Input Parameters

Attachment 6-20 |

Parameter Designation (Symbol)	Parameter Description	Dimensional Units	Numerical Value	Quantitative Distributional Information	Basis
<b>VII. Forebay &amp; Diffuser</b>					
<b>A. Forebay Dimensions</b>					
$X_{L-Forebay}$	Length of the Forebay, (Nominal)	ft.	400	Constant	Eng. Calc. EC 041-01(MY)
$X_{FW-Forebay}$	Floor Width of the Forebay, (Nominal)	ft.	160	Constant	Eng. Calc. EC 041-01(MY)
$X_{D-Forebay}$	Depth of the Forebay, (Nominal)	ft.	20	Constant	Eng. Calc. EC 041-01(MY)
$X_{TW-Forebay}$	Top Width of the Forebay, (Nominal)	ft.	210	Constant	Eng. Calc. EC 041-01(MY) (160+25+25)
$V_{Forebay}$	Forebay Volume	ft <sup>3</sup> m <sup>3</sup>	1.48E6 42,000	Constant	Eng. Calc. EC 041-01(MY) Midpoint of Rhombus ((160 + 25) x 400 x 20)
$A_{F-Forebay}$	Area of Forebay Floor	ft <sup>2</sup> m <sup>2</sup>	64,000 5948	Constant	Eng. Calc. EC 041-01(MY) (400 x 160)
$A_{S-Forebay}$	Area of Forebay Sides	ft <sup>2</sup> m <sup>2</sup>	16,000 1487	Constant	Eng. Calc. EC 041-01(MY) Assuming flat sides (2x400x20)
$A_{E-Forebay}$	Area of Forebay Ends	ft <sup>2</sup> m <sup>2</sup>	6880 639.2	Constant	Eng. Calc. EC 041-01(MY) ((160 + 12) x 20 x 2)
$A_{Rip\ Rap}$	Area of Rip Rap	ft <sup>2</sup> m <sup>2</sup>	25,132 2337	Constant	Eng. Calc. EC 041-01(MY) No. of 2ft. dia. half spheres that fit rectangularly in 16000 ft <sup>2</sup> = 4000
$V_{Rip\ Rap}$	Volume of Rip Rap	ft <sup>3</sup> m <sup>3</sup>	16755 478	Constant	Eng. Calc. EC 041-01(MY) Volume of 4000 2ft. dia spheres
<b>B. Forebay Dose Calculation</b>					



# Dose Model Input Parameters

Attachment 6-20

Parameter Designation (Symbol)	Parameter Description	Dimensional Units	Numerical Value	Quantitative Distributional Information	Basis
$U_T$	Annual Domestic and Irrigation Water Usage	m <sup>3</sup>	738	Constant	See Section I.A&B above
$N_{\text{Forebay Soil Fill}}$	Porosity of Forebay Soil Fill	Unitless	0.3	Constant	Conservatively selected based upon NUREG-5512, Vol. 3, Section 6.4.3, Table 6.41, pg. 6-64 Eng. Calc. EC 018-1
$N_{\text{Forebay Granite}}$	Porosity of Forebay Granite	Unitless	0.45	Constant	Conservatively selected based upon NUREG-5512, Vol. 3, Section 6.4.3, Table 6.41, pg. 6-64 ANL/EAD/LD-2
$NF_{\text{Sediment}}$	Sediment Nuclide Fraction	Unitless	Per Nuclide	Constant	MYLTP Attachment 2H
$K_{d-F\text{-Granite-All}}$	Forebay Granite Distribution Coefficient for All Nuclides	cm <sup>3</sup> /g	35	Constant	Assumption
$K_{d-F\text{-Soil-Co-60}}$	Forebay Soil Fill Distribution Coefficient for Co-60	cm <sup>3</sup> /g	493	Constant	MYLTP Attachment 6-2
$K_{d-F\text{-Soil-Cs-137}}$	Forebay Soil Fill Distribution Coefficient for Cs-137	cm <sup>3</sup> /g	1958	Constant	MYLTP Attachment 6-2
$K_{d-F\text{-Soil-Ni-63}}$	Forebay Soil Fill Distribution Coefficient for Ni-63	cm <sup>3</sup> /g	432	Constant	MYLTP Attachment 6-2
$K_{d-F\text{-Soil-Fe-55}}$	Forebay Soil Fill Distribution Coefficient for Fe-55	cm <sup>3</sup> /g	25	Constant	MYLTP Table 6-3
$K_{d-F\text{-Soil-Sb-125}}$	Forebay Soil Fill Distribution Coefficient for Sb-125	cm <sup>3</sup> /g	45	Constant	MYLTP Table 6-3

### Dose Model Input Parameters

Attachment 6-20

Parameter Designation (Symbol)	Parameter Description	Dimensional Units	Numerical Value	Quantitative Distributional Information	Basis
$\bar{\alpha}_{\text{FILL Forebay}}$	Forebay Fill Density	g/cm <sup>3</sup>	1.5	Constant	MYLTP Attachment 6-2 & Eng. Calc EC 041-01
$\bar{\alpha}_{\text{LEDGE Forebay}}$	Forebay Ledge Density	g/cm <sup>3</sup>	2.8	Constant	Eng. Calc EC 041-01 "Radiological Health Handbook"
$U_W$	Annual Drinking Water Volume	L/y	478	Constant	NRC DandD Version 1
DCF	Dose Conversion Factors	mrem/pCi	Per Nuclide	Constant	Federal Guidance Report No. 11
IR	Irrigation Rate	cm/y	10	Constant	USDA/NRCS see MYLTP Attachment 6-4
IR	Irrigation Rate	L/m <sup>2</sup> /d	0.274	Constant	Same as above (converted units)
$A_r$	Cultivated Area	m <sup>2</sup>	2400	Constant	NUREG-1727, App C, Section 2.3.2, pg. C12
H1	Thickness of surface-soil layer	m	0.15	Constant	NUREG-5512, Vol. 1, Table 6.23 pg. 6.42
$\text{Soil}_{SV}$	Surface Soil Screening Values	pCi/g	Per Nuclide	Constant	NUREG-1727, App C, Section 2.3.3, Table C2.3, pgs. C16-C17
$\bar{\alpha}_{\text{SOIL}}$	Soil Density	g/cm <sup>3</sup>	1.6	Constant	MYLTP Attachment 6-2

# Dose Model Input Parameters

Attachment 6-20

Parameter Designation (Symbol)	Parameter Description	Dimensional Units	Numerical Value	Quantitative Distributional Information	Basis
<b>C. Forebay Excavation Scenario</b>					
$X_{D \text{ dike cont zone}}$	Depth of Dike Contaminated Zone	ft.	2	Constant	MYLTP Attachment 2H
$\theta_{\text{dike}}$	Forebay Dike Angle from Horizon	degrees	30	Constant	Eng. Calc. EC 041-01(MY)
$A_{\text{excavated house}}$	Area of Excavated House	ft <sup>2</sup> Square	1000	Constant	Eng. Calc. EC 041-01(MY) NUREG 5512 Vol. 3, Sec 6.2.4.4.1
$X_{D \text{ excavated house}}$	Depth of Excavated House	ft.	10	Constant	Eng. Calc. EC 041-01(MY)
TI	Exposure Period: Indoors	day/yr	240	Constant	NUREG-5512, Vol. 3 Table 6.87, pg. 6-126
$X_{D \text{ Floor Thickness}}$	Floor Thickness (Shielding)	in.	6	Constant	Eng. Calc. EC 041-01(MY)
<b>D. Diffuser Dimensions</b>					
$N_{\text{Diffuser}}$	Number of Diffuser Pipes & Trunk Lines	Quantity	2	Constant	Eng. Calc. EC 041-01(MY)
$X_{\text{Diffuser Diameter}}$	Diameter of the Diffuser Pipes & Trunk Lines	ft.	9	Constant	Eng. Calc. EC 041-01(MY)
$X_{DP \text{ Length}}$	Length of the Diffuser Pipes	ft.	516	Constant	Eng. Calc. EC 041-01(MY)
$X_{TL \text{ Length}}$	Length of the Trunk Lines Submerged	ft.	1421.5	Constant	Eng. Calc. EC 041-01(MY)
$V_{\text{Diffuser Pipes}}$	Volume of the Diffuser Pipes	ft <sup>3</sup> m <sup>3</sup>	65,653 1860	Constant	Eng. Calc. EC 041-01(MY)
$SA_{\text{Diffuser Pipes}}$	Surface Area of the Diffuser Pipes	ft <sup>2</sup> m <sup>2</sup>	29,179 2711	Constant	Eng. Calc. EC 041-01(MY)

### Dose Model Input Parameters

Attachment 6-20

Parameter Designation (Symbol)	Parameter Description	Dimensional Units	Numerical Value	Quantitative Distributional Information	Basis
$V_{\text{Trunk Lines}}$	Volume of the Trunk Lines	ft <sup>3</sup> m <sup>3</sup>	90,432 2562	Constant	Eng. Calc. EC 041-01(MY)
$SA_{\text{Trunk Lines}}$	Surface Area of the Diffuser Pipes & Trunk Lines	ft <sup>2</sup> m <sup>2</sup> 100 cm <sup>2</sup>	71,981 6687 6.68E5	Constant	Eng. Calc. EC 041-01(MY) (conservatively overestimated by 2547 ft <sup>2</sup> )
<b>E. Diffuser Source Term</b>					
$I_{SA \text{ Diffuser}}$	Total Activity From the Surface Area of the Diffuser Pipes & Trunk Lines (Divided evenly between Cs-137 & Co-60)	μCi	30	Constant	Eng. Calc. EC 041-01(MY) Assumes each 100 cm <sup>2</sup> area contributes 100 dpm
$\bar{a}_{\text{Sediment Diffuser}}$	Diffuser Sediment Density	g/cm <sup>3</sup>	1.5	Constant	Eng. Calc EC 041-01(MY)
$I_{V \text{ Diffuser Co-60}}$	Co-60 Activity From the Volume of Sediment in the Diffuser Pipes & Trunk Lines	μCi	7300	Constant	Eng. Calc. EC 041-01(MY) Assumes ave Co-60 Activity of 1.1 pCi/g
$I_{V \text{ Diffuser Cs-137}}$	Cs-137 Activity From the Volume of Sediment in the Diffuser Pipes & Trunk Lines	μCi	995	Constant	Eng. Calc. EC 041-01(MY) Assumes ave Cs-137 Activity of 0.15 pCi/g
$I_{T \text{ Diffuser Co-60}}$	Total Co-60 Activity	μCi	7315	Constant	Eng. Calc. EC 041-01(MY)
$I_{T \text{ Diffuser Cs-137}}$	Total Cs-137 Activity	μCi	1010		Eng. Calc. EC 041-01(MY)
$I_{T \text{ Diffuser Sb-125}}$	Total Sb-125 Activity	μCi	64		Eng. Calc. EC 041-01(MY) Ratio from Co-60 using NF's in MYLTP Attachment 2H

### Dose Model Input Parameters

Attachment 6-20

Parameter Designation (Symbol)	Parameter Description	Dimensional Units	Numerical Value	Quantitative Distributional Information	Basis
$I_{T \text{ Diffuser Fe-55}}$	Total Fe-55 Activity	$\mu\text{Ci}$	2124		Eng. Calc. EC 041-01(MY) Ratio from Co-60 using NF's in MYLTP Attachment 2H
$I_{T \text{ Diffuser Ni-63}}$	Total Ni-63 Activity	$\mu\text{Ci}$	3000		Eng. Calc. EC 041-01(MY) Ratio from Co-60 using NF's in MYLTP Attachment 2H
<b>F. Diffuser Fish Ingestion Dose</b>					
$X_{L \text{ MZ}}$	Length of Mixing Zone	m	300	Constant	Eng. Calc. EC 041-01(MY) MYC-2035, Churchill (1980)
$X_{W \text{ MZ}}$	Width of Mixing Zone	m	175	Constant	Eng. Calc. EC 041-01(MY) MYC-2035, Churchill (1980)
$X_{D \text{ MZ}}$	Depth of Mixing Zone	m	15	Constant	Eng. Calc. EC 041-01(MY) MYC-2035, Churchill (1980)
$V_{\text{MZ}}$	Dilution Volume - Mixing Zone	$\text{m}^3$	786,000	Constant	Eng. Calc. EC 041-01(MY) MYC-2035, Churchill (1980)
$T_{\text{Tidal Flush}}$	Bay Turnover Time due to Tidal Flush	hrs.	56	Constant	Eng. Calc. EC 041-01(MY)
DCF	Dose Conversion Factors	mrem/pCi	per nuclide	Constant	Federal Guidance Report No. 11
$Ba_{jf \text{ Co-60}}$	Fish Bioaccumulation Factor for Co-60	pCi/kg wet weight per pCi/L	100	Constant	Reg Guide 1.109, Rev. 1, Table A-1, pg. 109-13
$Ba_{jf \text{ Cs-137}}$	Fish Bioaccumulation Factor for Cs-137	pCi/kg wet weight per pCi/L	40	Constant	Reg Guide 1.109, Rev. 1, Table A-1, pg. 109-13

# Dose Model Input Parameters

Attachment 6-20

Parameter Designation (Symbol)	Parameter Description	Dimensional Units	Numerical Value	Quantitative Distributional Information	Basis
Ba <sub>jf</sub> Sb-125	Fish Bioaccumulation Factor for Sb-125	pCi/kg wet weight per pCi/L	200	Constant	NUREG/CR-5512, Vol. 3, Section 6.4.1, Table 6-30, Part 3, pg. 6-54
Ba <sub>jf</sub> Fe-55	Fish Bioaccumulation Factor for Fe-55	pCi/kg wet weight per pCi/L	3000	Constant	Reg Guide 1.109, Rev. 1, Table A-1, pg. 109-13
Ba <sub>jf</sub> Ni-63	Fish Bioaccumulation Factor for Ni-63	pCi/kg wet weight per pCi/L	100	Constant	Reg Guide 1.109, Rev. 1, Table A-1, pg. 109-13
Ba <sub>jsf</sub> Co-60	Shell Fish Bioaccumulation Factor for Co-60	pCi/kg wet weight per pCi/L	1000	Constant	Reg Guide 1.109, Rev. 1, Table A-1, pg. 109-13
Ba <sub>jsf</sub> Cs-137	Shell Fish Bioaccumulation Factor for Cs-137	pCi/kg wet weight per pCi/L	25	Constant	Reg Guide 1.109, Rev. 1, Table A-1, pg. 109-13
Ba <sub>jsf</sub> Sb-125	Shell Fish Bioaccumulation Factor for Sb-125	pCi/kg wet weight per pCi/L	200	Constant	NUREG/CR-5512, Vol. 3, Section 6.4.1, Table 6-30, Part 3, pg. 6-54
Ba <sub>jsf</sub> Fe-55	Shell Fish Bioaccumulation Factor for Fe-55	pCi/kg wet weight per pCi/L	20,000	Constant	Reg Guide 1.109, Rev. 1, Table A-1, pg. 109-13
Ba <sub>jsf</sub> Ni-63	Shell Fish Bioaccumulation Factor for Ni-63	pCi/kg wet weight per pCi/L	250	Constant	Reg Guide 1.109, Rev. 1, Table A-1, pg. 109-13

**Dose Model Input Parameters**

Attachment 6-20

<b>Parameter Designation (Symbol)</b>	<b>Parameter Description</b>	<b>Dimensional Units</b>	<b>Numerical Value</b>	<b>Quantitative Distributional Information</b>	<b>Basis</b>
$U_f$	Fish Consumption	kg/y	20.6	Constant	NRC DandD Version 1 NUREG/CR-5512 Vol. 3, Section 6.2.9 and Table 6.87, pg. 6-127
$U_{sf}$	Shell Fish Consumption	kg/y	1	Constant	Reg. Guide 1.109, Rev. 1, App. E, Table E-4, pg. 1.109-39
<b>G. Diffuser Sediment Direct Radiation Dose</b>					
$A_{\text{Bailey Cove}}$	Area of Bailey Cove Mudflat	m <sup>2</sup>	130,000	Constant	Eng. Calc. EC 041-01(MY)
$A_{\text{Mixing Zone}}$	Area of Mixing Zone	m <sup>2</sup>	52,500	Constant	Eng. Calc. EC 041-01(MY) (300m x 175m)
WF	Shoreline Width Factor (tidal basin)	unitless	1	Constant	Reg. Guide 1.109, Rev. 1, App. A, Table A-2, pg. 1.109-15
$T_{\text{Mud Flats}}$	Exposure Period of Commercial Worm Digger on Bailey Cove Mud Flats	hr.	325	Constant	Maine Yankee Offsite Dose Calculation Manual
TX	Exposure Period Outdoors	days hr.	40.2 964	Constant	NUREG/CR-5512 Vol. 3, Section 6.2.3, Table 6.12, pg. 6-20

**Dose Model Input Parameters**  
**RESRAD Input Parameters**

Attachment 6-20

For the Deep Soil and Buried Pipe Dose Models, Maine Yankee used RESRAD as the transport code to determine water concentration from consequentially contaminated soil using stated site specific or default parameters. In the interest of more clearly communicating the workings of the dose models used in the LTP, the Input Parameters and Active Pathways for these uses of RESRAD are presented in the following table. NUREG-5512 provides mean values of various dose model parameters as well as values based on the 90% CI of the parameter distribution. Default values derived from the NUREG-5512 probability distribution are indicated by "90%CI".

<b>Parameter Designation (Symbol)</b>	<b>Parameter Description</b>	<b>NUREG-5512 Default Value</b>	<b>NUREG-5512 Mean Value</b>	<b>MY LTP Value Used</b>	<b>Reference</b>
TTR	Total time in 1-year exposure period	365.25 d	365.25 d	365.25 d	Constant
TD	Drinking-water consumption period	365.25 d	365.25 d	365.25 d	Constant
TF	Fish consumption period	365.25 d	365.25 d	365.25 d	Constant
TTG	Total time in gardening period	90 d	90 d	90 d	90% CI
TI	Exposure period: indoors	200 d/y	240 d/y	240 d/y	LTP 6.6.5.b (90% CI)
TX	Exposure period: outdoors	70.8 d/y	40.2 d/y	40 d/y	LTP 6.6.1.c3 (90% CI)
TG	Exposure period: gardening	4.2 d/y	2.9 d/y	2.9 d/y	90% CI
SFO	Outdoor shielding factor	1	1	1	Constant-no credit for shielding
UW	Drinking water ingestion rate	2 L/d	1.31 L/d	1.31 L/d	LTP 6.6.1.c1 (Hydrogeological Consultant)
H1	Thickness of surface soil layer	0.15 m		0.15 m	LTP 6.6.4.a (MARSSIM)



**Dose Model Input Parameters**  
**RESRAD Input Parameters**

Attachment 6-20

<b>Parameter Designation (Symbol)</b>	<b>Parameter Description</b>	<b>NUREG-5512 Default Value</b>	<b>NUREG-5512 Mean Value</b>	<b>MY LTP Value Used</b>	<b>Reference</b>
H2	Thickness of unsaturated zone	1 m	22 m	0 m	EC005-01(MY) (Hydrogeological Consultant)
N1	Porosity of surface soil	0.4	0.47	0.3	LTP 6.6.1.b (Site Specific Test)
N2	Porosity of unsaturated zone	0.4	0.46	0.3	LTP 6.6.1.b (Site Specific Test)
F1	Saturation ratio for surface soil layer	0.16	0.49	Not used	N/A
F2	Saturation ratio for unsaturated soil layer	0.16	0.49	Not used	N/A
VDR	Volume of water for domestic use	9.12E5 L/y	1.18E5 L/y (1.24E5 L/y Maine)	7.38E5 L/y	LTP 6.6.1.b (Hydrogeological Consultant) & NRC DandD Version 1
I	Infiltration rate	0.252 m/y	0.119 m/y	0.0672 m/y	LTP 6.6.4.a, See Note 1 (Hydrogeological Consultant)
AR	Area of cultivated land	2500 m <sup>2</sup>	2400 m <sup>2</sup>	2400 m <sup>2</sup>	LTP 6.6.1.d5 (90% CI)
IR	Irrigation rate	2.08 L/m <sup>2</sup> -d	1.29 L/m <sup>2</sup> -d	0.274 L/m <sup>2</sup> -d	LTP 6.6.1.c2 Extension Letter
PS	Soil areal density of surface layer	214 kg/m <sup>2</sup>	212 kg/m <sup>2</sup>	240 kg/m <sup>2</sup>	Site Specific =RHO1 * H1 <sub>vol</sub>
UF	Human diet of fish	20.6 kg/y	20.6 kg/y	20.6 kg/y	LTP 6.6.7 (90% CI)

**Dose Model Input Parameters**  
**RESRAD Input Parameters**

Attachment 6-20

<b>Parameter Designation (Symbol)</b>	<b>Parameter Description</b>	<b>NUREG-5512 Default Value</b>	<b>NUREG-5512 Mean Value</b>	<b>MY LTP Value Used</b>	<b>Reference</b>
BA	Fish bioaccumulation factor	1.0 H-3	5512 didn't differentiate between ocean and shell fish	1.0 H-3 100 Co-60 40 Cs-137 200 Sb-125 3000 Fe-55 100 Ni-63	Default Reg. Guide 1.109
RHO1	Surface soil density		1.41 g/mL	1.6 g/mL	LTP 6.6.1.d10 (Site Specific Test)
RHO2	Unsaturated zone soil density		1.41 g/mL	1.6 g/mL	LTP 6.6.1.d10 (Site Specific Test)
	Soil cover density			1.5 g/mL	LTP 6.6.1.d9 (Site Specific Test)

**Dose Model Input Parameters**  
**RESRAD Input Parameters**

Attachment 6-20

Parameter Designation (Symbol)	Parameter Description	NUREG-5512 Default Value	NUREG-5512 Mean Value	MY LTP Value Used	Reference																					
Kd	Partition (distribution) coefficients for surface soil and unsaturated layers, including basement fill material	H-3 1 Cs 270 Co 60 Sr 15		<table><tr><td></td><td>Flow</td><td></td></tr><tr><td></td><td>Fill</td><td>Fill</td></tr><tr><td>H-3</td><td>0</td><td>0</td></tr><tr><td>Cs</td><td>1958</td><td>79</td></tr><tr><td>Co</td><td>493</td><td>128</td></tr><tr><td>Sr</td><td>239</td><td>60</td></tr><tr><td>Ni</td><td>432</td><td>-</td></tr></table>		Flow			Fill	Fill	H-3	0	0	Cs	1958	79	Co	493	128	Sr	239	60	Ni	432	-	LTP Table 6-3 (Site Specific Test)
	Flow																									
	Fill	Fill																								
H-3	0	0																								
Cs	1958	79																								
Co	493	128																								
Sr	239	60																								
Ni	432	-																								
RESRAD Deep Soil and Buried Pipe Model Parameters																										
Kd	Partition (distribution) coefficients for deep soil	H-3 1 Cs 270 Co 60 Sr 15		<table><tr><td>H-3</td><td>0</td></tr><tr><td>Cs</td><td>1200</td></tr><tr><td>Co</td><td>335</td></tr><tr><td>Sr</td><td>152</td></tr><tr><td>Ni</td><td>274</td></tr></table>	H-3	0	Cs	1200	Co	335	Sr	152	Ni	274	LTP Table 6-8 (Site Specific Test)											
H-3	0																									
Cs	1200																									
Co	335																									
Sr	152																									
Ni	274																									
DCFs	Dose Conversion Factors by nuclide			defaults	FGR-11																					
RTFs	Food Transfer Factors			not used	N/A																					
BIOFACs	Bioaccumulation factors			not used	N/A																					
R011	Length parallel to aquifer	100 m		Based on 10,000 m <sup>2</sup> soil area	EC 005-01(MY)																					
R011	Time Since placement of material			0 yrs	EC 005-01(MY) Max Concern.																					
R012	Initial nuclide concentration			1 pCi/g	EC005-01(MY)																					

**Dose Model Input Parameters**  
**RESRAD Input Parameters**

Attachment 6-20

<b>Parameter Designation (Symbol)</b>	<b>Parameter Description</b>	<b>NUREG-5512 Default Value</b>	<b>NUREG-5512 Mean Value</b>	<b>MY LTP Value Used</b>	<b>Reference</b>
R012	Concentration in ground water			not used	N/A
R013	Cover depth	0 m		0.15 m	EC005-01(MY) (MARSSIM)
R013	Density	1.5 g/mL		not used	N/A
R013	Erosion rate	0.001 m/y		0.001 m/y	90% CI
R013	Contaminated zone density	1.5 g/mL		1.6 g/mL	LTP 6.6.1.d10 (Site Specific Test)
R013	Contaminated zone erosion rate	0.001		0.001	90% CI
R013	Contaminated zone porosity	0.4		0.3	(Site Specific Test)
R013	Contaminated zone field capacity	0.2		0.2	90% CI
R013	Contaminated zone hydraulic conductivity	10 m/y		32 m/y	LTP Table 6-8 (Hydrogeological Consultant)
R013	Contaminated Zone b parameter	5.3		4.05	LTP Table 6-8 (Hydrogeological Consultant)
R013	Average annual wind speed	2 m/s		2 m/s	90% CI
R013	Humidity	8 g/m3		not used	N/A
R013	Evapotranspiration coefficient	0.5		0.5	90% CI
R013	Precipitation	1 m/y		1 m/y	90% CI
R013	Irrigation rate	0.2 m/y		0.2 m/y	EC005-01(MY)

**Dose Model Input Parameters**  
**RESRAD Input Parameters**

Attachment 6-20 |

<b>Parameter Designation (Symbol)</b>	<b>Parameter Description</b>	<b>NUREG-5512 Default Value</b>	<b>NUREG-5512 Mean Value</b>	<b>MY LTP Value Used</b>	<b>Reference</b>
R013	Irrigation mode	overhead		overhead	EC005-01(MY)
R013	Runoff Coefficient	0.2		0.2	90% CI
R013	Pond watershed area	1E6 m2		1E6 m2	90% CI
R013	Accuracy	0.001		0.001	90% CI
R014	Saturated zone density	1.5 g/mL		1.6 g/mL	EC005-01(MY)
R014	Saturated zone total porosity	0.4		0.3	LTP 6.6.1.b (Site Specific Test)
R014	Saturated zone effective porosity	0.2		0.01	LTP Table 6-8 (Hydrogeological Consultant)
R014	Saturated zone field capacity	0.2		0.2	90% CI
R014	Saturated zone hydraulic conductivity	100 m/y		32 m/y	LTP Table 6-8 (Hydrogeological Consultant)
R014	Saturated zone hydraulic gradient	0.02		0.02	90% CI
R014	Saturated zone b parameter	5.3		4.05	EC005-01(MY) (Hydrogeological Consultant)
R014	Water table drop rate	0.001 m/y		0.001 m/y	90% CI
R014	Well pump intake depth	10 m		10 m	90% CI
R014	Model	ND		ND	EC005-01(MY)
R014	Well pumping rate	250 m3/y		not used	N/A

**Dose Model Input Parameters**  
**RESRAD Input Parameters**

Attachment 6-20

<b>Parameter Designation (Symbol)</b>	<b>Parameter Description</b>	<b>NUREG-5512 Default Value</b>	<b>NUREG-5512 Mean Value</b>	<b>MY LTP Value Used</b>	<b>Reference</b>
R015	Unsaturated zone strata	1		1	RESRAD Default
R015	Unsaturated zone thickness	4 m		0	EC005-01(MY) (Hydrogeological Consultant)
R015	Unsaturated zone density	1.5 g/mL		1.6 g/mL	EC005-01(MY) (Site Specific Test)
R015	Unsaturated zone total porosity	0.4		0.3	LTP 6.6.1.b (Site Specific Test)
R015	Unsaturated zone effective porosity	0.2		0.2	90% CI
R015	Unsaturated zone field capacity	0.2		0.2	90% CI
R015	Unsaturated zone b parameter	5.3		4.05	EC005-01(MY) (Hydrogeological Consultant)
R015	Unsaturated zone hydraulic conductivity	10 m/y		1000 m/y	LTP Table 6-8 (Hydrogeological Consultant)
R016	Kds nuclide site specific values given above			See above	Site Specific
R017	Only the "Exposure Duration" used	30 y		Annual dose used. Based on peak water concentration.	EC 005-01(MY)
R018	Only "Drinking Water Intake" and "Fraction Contaminated" are used	510 L/y 1.0		478.5 L/y 1.0	EC005-01(MY) NRC DandD Version 1

**Dose Model Input Parameters**  
**RESRAD Input Parameters**

Attachment 6-20

Parameter Designation (Symbol)	Parameter Description	NUREG-5512 Default Value	NUREG-5512 Mean Value	MY LTP Value Used	Reference
R019	Only "Drinking Water Fraction From Groundwater" used	1.0		1.0	EC005-01(MY)
R19B	Not used			not used	N/A
C14	Not used			not used	N/A
STOR	Not used			not used	N/A
R021	Not used			not used	N/A

RESRAD Pathways: All pathways except (7) "Drinking Water" are inactive.

Time increments for RESRAD dose calculation are as listed to capture the peak nuclide concentration

The following Engineering Calculations\* were reviewed to identify the parameters listed above:

- EC-001-00 Concrete Structures - Miscellaneous Volume and Surface Area Calculations, Rev. 0, dated 10/25/2001
- EC-022-00 Contaminated & Activated Concrete Dose Assessment and Unitized Dose Factors, Rev. 2 dated 8/21/2002
- EC-003-01 Embedded Piping Dose Assessment and Unitized Dose Factors, Rev. 2, dated 8/29/2002
- EC-005-01 Deep Soil Dose Assessment and Unitized Dose Factors, Rev. 3, dated 4/30/2002
- EC-006-01 Groundwater Dose Assessment and Unitized Dose Factors, Rev. 2, dated 1/8/2002
- EC-007-01 Surface Water Dose Assessment and Unitized Dose Factors, Rev. 1, dated 3/25/2001
- EC-010-01 Instrument Sensitivity, Rev. 4, dated 11/26/2002
- EC-011-01 Contaminated Concrete Nuclide Profile Evaluation, Rev. 2, dated 9/16/2002
- EC-012-01 Activated Concrete Nuclide Profile, Rev. 0, dated 3/28/2001
- EC-013-01 Contaminated Soil Radionuclide Profile, Rev. 0, dated 3/27/2001
- EC-014-01 Summation of Doses and Selection of DCGLs for All Contaminated Materials, Rev. 2, dated 9/11/2002
- EC-017-01 Buried Piping Dose Assessment and Unitized Dose Factors, Rev. 2, dated 8/21/2002
- EC-018-01 Basement Fill Material Kd's, Rev. 1, dated 4/17/2002
- EC-041-01 Diffuser and Forebay Dose Assessment, Rev. 0, dated 9/5/2002

\* Copies of the Engineering Calculations were provided to the State through 12/10/2002 (See Cesare E-mail to Dostie dated 12/10/2002)

**Dose Model Input Parameters**  
**RESRAD Input Parameters**

Attachment 6-20 |

The following references were used to identify the partition factor parameters listed above:

- Onishi-1981: USNRC NUREG/CR-1322 "Critical Review: Radionuclide Transport, Sediment Transport, and Water Quality Mathematical Modeling; and Radionuclide Adsorption/Desorption Mechanisms", January 1981
- Baes-1984: Oak Ridge National Laboratory ORNL-5786 "A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture", September 1984
- Krupa-1998: USNRC NUREG/CR-6377 "Effects on Radionuclide Concentrations by Cement/Ground-Water Interactions in Support of Performance Assessment of Low-Level Radioactive Waste Disposal Facilities", May 1998
- Sheppard-1990 Health Physics Vol. 59, No. 4 (October 1990) pp 471-482, "Default Soil Solid/Liquid Partition Coefficients,  $K_d$ 's, for Four Major Soil Types: A Compendium"

Note:

1. The Infiltration Rate was not an input parameter in the RESRAD dose assessment for deep soil; rather, it is derived from other input parameters such as the saturated hydraulic conductivity, the precipitation rate, the irrigation rate and the run-off coefficient in accordance with the procedure described in NUREG 5512, Vol. 3, Section 6.4.3.4.3, pgs 6-64 through 6-67. The Infiltration Rate is presented for comparison purposes. In Rev. 0 of the Dose Model Input Parameters list, a value of "less than 3155.8 m/y" was presented. This came from MYLTP Section 6.6.4.a, where Maine Yankee indicated that the average saturated hydraulic conductivity rate of 0.01 cm/s (3155 m/y) is greater than the infiltration rate.



**MAINE YANKEE**

**LTP SECTION 7**

**UPDATE OF SITE- SPECIFIC DECOMMISSIONING COSTS**

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## **7.0 UPDATE OF SITE- SPECIFIC DECOMMISSIONING COSTS**

### **7.1 Introduction**

In accordance with 10 CFR 50.82(a)(9)(ii)(F) and the guidance of Regulatory Guide 1.179, the site-specific cost estimates and funding plans are provided.

### **7.2 Decommissioning Cost Estimate**

The current decommissioning cost estimate and cost estimate for management of spent fuel and GTCC waste Docket # ER16-2726 was filed with the Federal Energy Regulatory Commission (FERC) on September 30, 2016 and approved by FERC on November 15, 2016 with no objections from the State agencies that were party to the April 30, 2013 Stipulation and Settlement Agreement (Docket # ER13-1396-000) including the Connecticut Public Utilities Regulatory Authority, the Connecticut Office of Consumer Counsel, the Maine Public Utilities Commission, the Maine Office of Public Advocate, the Massachusetts Department of Public Utilities, and the Attorney General of Massachusetts.

This cost estimate includes the cost associated with the projected ISFSI decommissioning costs and a funding assumption of 15 years of operations costs to manage spent fuel and GTCC waste. A funding mechanism provides that damage awards and settlement proceeds that MYAPCO receives in future phases of its litigation with the Department of Energy (DOE) will be applied to maintain the adequacy of the Nuclear Decommissioning Trust (NDT) to cover 15 years of ISFSI operations (as well as all other projected decommissioning costs). In addition, MYAPCO has the right to resume collection of decommissioning charges from its customers subject to the submittal of a proposal under section 205 of the Federal Power Act, if needed.

MYAPCO has an account within its NDT entitled, "ISFSI Radiological Decom," that segregates the funds for radiological decommissioning of the ISFSI from the larger balance of funds for ongoing management of spent fuel and GTCC waste held in the NDT.

The assumptions of the current decommissioning cost estimate are discussed in the Decommissioning Funding Plan submitted to the NRC on December 16, 2015 in accordance with 10 CFR 72.30(c) (Reference 7.3-1). The decommissioning cost estimate incorporates the most recent assumptions with respect to the remaining decommissioning activities and related costs (i.e., those associated with the Maine Yankee ISFSI). The total un-escalated cost estimate for decommissioning the ISFSI, including contingency is approximately \$28.1 million in 2016 dollars. This includes approximately \$22.1 million

for radiological removal in 2016 dollars and approximately \$6.0 million for non-radiological removal in 2016 dollars.

MYAPCO will continue to inform the NRC regarding the status of this funding by complying with the obligations defined in: 1) 10 CFR 50.75(f)(1) and (2) to submit an annual Decommissioning Funding Status Report; 2) 10 CFR 50.82(a)(8)(v) to submit an annual financial assurance status report regarding decommissioning funding; and 3) 10 CFR 72.30(c) to resubmit the decommissioning funding plan at intervals not to exceed three years.

### 7.3    References

- 7.3-1   Letter from C. Pizzella (MYAPCO) to U.S. Nuclear Regulatory Commission, OMY-15-053, "Three-Year Update to the Independent Spent Fuel Storage Installation Decommissioning Funding Plan," dated December 16, 2015.

**MAINE YANKEE**  
**LTP SECTION 8**  
**SUPPLEMENT TO THE ENVIRONMENTAL REPORT**

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## 8.0 SUPPLEMENT TO THE ENVIRONMENTAL REPORT

### 8.1 Introduction and Purpose

#### 8.1.1 Purpose

The purpose of this section of the License Termination Plan (LTP) is to update the Maine Yankee Environmental Report (MYER) with any new information or significant environmental change associated with Maine Yankee's proposed decommissioning/license termination activities. This section of the LTP constitutes a supplement to the MYER pursuant to 10 CFR 51.53(d) "Environmental Report Post-Operating License Stage" and 10 CFR 50.82(a)(9)(ii)(G). In October, 1970, Maine Yankee submitted to the US. Atomic Energy Commission (AEC: NRC's predecessor) its Environmental Report, which was further appended in February 1971 with supplementary information. On April 19, 1972, Maine Yankee submitted to the AEC a "Supplement to Environmental Report." It is this latest supplement which is being updated by this LTP section pursuant to the above regulations. During July 1972 the AEC issued the Final Environmental Statement related to the operation of Maine Yankee Atomic Power Station. On August 27, 1997, shortly after submitting its 10 CFR 50.82(a)(1) shutdown certifications, Maine Yankee submitted its Post Shutdown Decommissioning Activities Report (PSDAR).

This supplement to the MYER describes changes since the issuance of the PSDAR and the MYER. Any identified new information or significant environmental change associated with Maine Yankee's proposed decommissioning/license termination activities is evaluated to determine whether it is bounded by the site-specific decommissioning activities described in Maine Yankee's PSDAR, AEC's Final Environmental Statement or the Final Generic Environmental Impact Statement (FGEIS), NUREG - 0586. Maine Yankee's proposed decommissioning/license termination activities are bounded by AEC's Final Environmental Statement (FGEIS), NUREG-0586 and/or the impacts of the reference plant evaluated therein (Reference 8.9.5).

This supplement to the environmental report generally follows the NRC guidance of Regulatory Guide 1.179 "Standard Format and Content of License Termination Plans for Nuclear Power Reactors," dated January 1999 and NUREG-1700 "Standard Review Plan for Evaluating Nuclear Power Reactor License Termination Plans," dated April 2000. The contents of this section have been informed by appropriate sections of NUREG-1727 "NMSS Decommissioning Standard Review Plan," dated September 15, 2000. Much of the information specified in this later guidance document has been previously provided to the



NRC in other forms; e.g., Defueled Safety Analysis Report (DSAR) - site description, meteorology, seismology, hydrology etc.

#### 8.1.2 Site Description After Unrestricted Release

A summary description of the site following license termination and unrestricted release is provided in Section 8.2. Unrestricted release, in this usage, refers to demonstration of release in terms of radiological criteria, as defined in 10 CFR 20.1402. As of September 30, 2005, the only decommissioning activities that remain are those associated with the ISFSI. The information included in this section of the LTP includes historical information regarding the decommissioning of the Maine Yankee Nuclear Plant that will be maintained in its current form. This information will be reviewed, and revised as necessary, at the time of initiating the decommissioning activities for the ISFSI and associated land areas to ensure that appropriate information is available for the implementation of final status survey activities for the ISFSI and termination of the Part 50 License for the Maine Yankee site.

Generally, the above grade structures for the Maine Yankee Nuclear Plant were demolished down to three feet below grade and the resulting concrete demolition debris was disposed of offsite at either a low-level radioactive waste facility or an appropriate disposal facility. The remaining basement foundations were filled with a soil fill material following any required remediation and final status survey activities. The ISFSI storage pads and Vertical Concrete Casks will be dismantled and all of the material (concrete and steel) disposed of as low-level radioactive waste. This section identifies radiological and non-radiological impacts associated with the final state of the site.

#### 8.1.3 PSDAR Update For Remaining Dismantlement and Decontamination Activities

LTP Section 3 identifies the dismantlement and decontamination activities which remain to be completed to allow license termination and unrestricted release. These activities are compared to the descriptions given in the PSDAR and any changes identified. The impacts of the changes to these activities are described in Section 8.3.

#### 8.1.4 Update of Maine Yankee Environmental Report

The MYER was reviewed against Maine Yankee's proposed decommissioning/license termination activities to identify relevant new information or significant environmental changes associated with those activities. Any relevant new information or significant environmental changes identified

were reviewed to determine whether they are bounded by the site specific decommissioning activities described in the PSDAR, the AEC's Final Environmental Statement for Maine Yankee or the FGEIS, NUREG-0586. Maine Yankee's proposed decommissioning/license termination activities are bounded by AEC's Final Environmental Statement (FGEIS), NUREG-0586 and/or the impacts of the reference plant evaluated therein (Reference 8.9.5). A description of this review is provided in Section 8.4

#### 8.1.5 Radiological Environmental Impacts

A description of the radiological impacts of the site following license termination and unrestricted release is provided in Section 8.5.1. These radiological impacts are identified generally following the guidance provided by the NRC in NUREG-1727 "NMSS Decommissioning Standard Review Plan" dated September 15, 2000. The models and modeling results are described in LTP Section 6. That LTP section shows how Maine Yankee meets the Radiological Criteria for License termination prescribed in 10 CFR Part 20, Subpart E and the enhanced state criteria described in Maine State Law LD 38MRS §1455.

The radiological impact of plant operation versus the site following license termination and unrestricted release is also discussed in Section 8.5.2. During approximately twenty-five years of operation, Maine Yankee operated well within the limits prescribed in the applicable radiological effluent requirements. With the cessation of operations and the completion of the decommissioning of the Maine Yankee Nuclear Plant, with the exception of those activities associated with the ISFSI, the radiological impacts of the facility have decreased due to both the elimination of effluents (both liquid and gaseous) and the reduction in source term due to radioactive decay. Following license termination and unrestricted release, the radiological impacts are assessed against a postulated member of a group of individuals reasonably expected to receive the greatest exposure to residual radioactivity for any applicable set of circumstances. The radiological impact to real individuals under realistic circumstances are expected to be much less than this postulated, low probability situation and are expected to be much less than for plant operation.

#### 8.1.6 Non Radiological Environmental Impacts

The non-radiological impacts of decommissioning activities associated with termination of the license are described in Section 8.6. These non-radiological impacts include: water usage, non-radiological waste generation and transportation, dismantlement and excavation controls. Other non-radiological concerns which are covered by federal, state and local agencies other than the NRC are generally described. More information on the responsibilities of these

agencies and Maine Yankee's coordination with these agencies is presented in LTP Section 3.6.

#### 8.1.7 Evaluation of Decommissioning Low-Level Radioactive Waste (LLRW) Volume

The waste volume generated from the decommissioning of Maine Yankee is described and its impact is evaluated in Section 8.7. This waste volume is greater than that which was originally described in the PSDAR. The increase in volume is a result of the decision to dispose of all concrete demolition debris from structures above grade (above three feet below grade) at either a low-level radioactive waste facility or an appropriate disposal facility. In addition, the ISFSI storage pads and Vertical Concrete Casks will be dismantled and all of the material (concrete and steel) disposed of as low-level radioactive waste. The impacts of this volume are evaluated against the basis for the estimates provided in the FGEIS. In particular, the impacts on LLRW disposal facility resources and the dose to the public resulting from waste transportation are evaluated and described.

#### 8.1.8 Summary/Conclusion

Section 8.8 summarizes the relevant new information and significant environmental changes identified and the evaluation of their corresponding impacts. It is concluded that Maine Yankee's proposed decommissioning/license termination activities are bounded by AEC's Final Environmental Statement (FGEIS), NUREG-0586 and/or the impacts of the reference plant evaluated therein. Identified changes between this supplement and the previously submitted documents will be expanded upon in the text of this document.

### 8.2 Site Description after License Termination

The purpose of this section is to present a summary of the final state of the site following license termination and unrestricted release and to identify relevant radiological and non-radiological impacts. Unrestricted release, in this usage, refers to the radiological release criteria of 10 CFR 20.1402. (It is possible that due to non-radiological considerations, some portion of the site may be subject to deed restrictions regarding certain activities. See Section 8.6.13.) LTP Section 3.2.4 provides a more detailed description of the final state of the site following dismantlement activities. The impacts identified in this section are discussed in Sections 8.5 and 8.6.

At license termination, when the site will be released for unrestricted use, the site will be a backfilled and graded land area with some above grade structures remaining depending on the industrial reuse of the site. Remaining above grade structures include the main switchyard and possibly other buildings which were used for administrative, non-

radiological purposes. Generally speaking, the rest of the above grade structures associated with the Maine Yankee Nuclear Plant were demolished down to three feet below grade and the resulting concrete demolition debris was disposed of offsite at either a LLRW disposal facility or an appropriate disposal facility. The remaining basement foundations were filled with a soil fill material following any required remediation and final status survey activities. In addition, the ISFSI storage pads and Vertical Concrete Casks will be dismantled and all of the material (concrete and steel) disposed of as low-level radioactive waste.

The former Low Level Waste Storage Building [now the ISFSI Security Operations Building-(SOB)] will remain in place until the fuel is transferred to the Department of Energy. The 115 kv switchyard, the 345 kv switchyard, the barge slip and dolphins will remain intact. The road that travels west of the ISFSI will remain in place, terminating near the 115 kv switchyard. The original plant access road will remain. The existing railroad will remain in place. The Old Ferry Road and public boat ramp will remain in place. Some below grade structures and systems will remain.

The foundation basements of the Containment, Primary Auxiliary Building, Fuel Building and Containment Spray Building will remain in place below an elevation equivalent to three feet below grade. Other above grade structures such as the Turbine Building, Service Building, WART Building, Front Office, Circulating Water Pump House, RCA Building, High Radiation Bunker, Main Steam and Valve House, Emergency Feedwater Pump Room, LSA Building, Equipment Hatch and HV-7 and 9 Rooms, Ventilation Equipment Area and the Reactor Motor Control Center Room were demolished such that primarily only foundation remnants below an elevation equivalent to nominally three feet below grade will be left. The radiological contamination and activation products in the basements and grade level foundations were cleaned up and surveyed in accordance with the radiological criteria and survey methods described in LTP Sections 3 through 6. Non-radiological contaminants in these buildings included paint that contains low levels of PCB. These and other non-radiological contaminants were addressed in the RCRA closure process.

System piping such as Primary Component Cooling, Secondary Component Cooling, sanitary sewer in the industrial area and fuel oil and piping between the DWST/RWST and the Spray Building were removed. Following piping removal, the excavations were remediated as necessary and surveyed in accordance with the radiological criteria and survey methods described in LTP Sections 3 through 6. Non-radiological contaminants that were carried in these pipes include chromates and fuel oil. These and other non-radiological contaminants were addressed in the RCRA closure process.

Portions of the Service Water (SW), Circulating Water (CW), Fire Water, and storm water drain pipes, and duct banks remain buried. Most of these pipes/duct banks were not radiologically contaminated with the possible exception of the storm water drain pipes from the restricted area. These pipes were remediated, if necessary, and surveyed in

accordance with the radiological criteria and survey methods described in LTP Sections 3 through 6. Non-radiological contaminants were addressed in the RCRA closure plan.

Maine Yankee evaluated the final disposition of the forebay, seal pit, and diffuser piping, as part of the comprehensive application for permit under the Natural Resource Protection Act (NRPA). The Maine Yankee permit application was filed with the State of Maine in October 2001 (Reference 8.9.25), was conditionally approved in February 2002 (Reference 8.9.27), with final approval given in February 2003 (Reference 8.9.40). As part of the Comprehensive NRPA application, Maine Yankee analyzed remedial options and coordinated, as required, with the Maine Department of Environmental Protection, and the U.S. Army Corps of Engineers. (Other responsible agencies coordinate through these two principal agencies.) The key options evaluated included: (1) leave in place as exists; (2) secure and leave in place; (3) partial removal and; (4) complete removal. The types of impact considered in the analyses included environmental impacts (water quality, marine wetlands, freshwater wetlands and land use), ecological impacts including flora, fauna and marine resources, and impacts on natural resources and navigation. Maine Yankee's assessment resulted in the following summary recommendations for the key elements of the plant's discharge structures, as presented in the Comprehensive NRPA application:

Diffuser Pipe, Foxbird Island - onshore below grade. Leave in place with both end back-filled or plugged.

Diffuser Pipe, Mudflats - below the sediment/water interface. Leave in place.

Diffuser Pipe, offshore above the sediment/water interface. Leave in place, including the concrete saddle supports and thrust blocks.

Forebay and Seal Pit. Reduction of forebay dike elevation to approximately 10', remediation of forebay and seal pit interior, removal of concrete structures at both ends of the forebay to an elevation three feet below grade, fill area between dikes with appropriate back-fill material, stabilize and revegetate areas to match existing features, pending further consideration of alternative remedial options.<sup>1</sup>

The impacts of the decommissioning of the forebay and diffuser piping are described (in summary fashion) in Section 8.4.1 below and (in detail) in Section 8.6.4 which discusses the evaluation of the remediation work under NRPA. As described in Section 8.6.4, the

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<sup>1</sup> As noted above, these remediation approaches for the key elements of the plant's discharge structures represent Maine Yankee's recommendations as presented in the Comprehensive NRPA application (Reference 8.9.25). As discussed in Section 8.6.4, MDEP granted a conditional approval of the work described in Maine Yankee's application. Final implementation of the forebay remediation was reviewed by the MDEP in Maine Yankee's "Phase II" forebay remediation plan which contained an updated and final assessment of remedial options. See Section 8.6.4 for additional detail on the NRPA review process.

NRPA applications, agency approvals, and other relevant documents were submitted to the NRC to support its review of this supplement to the environmental report. (See Section 8.9, References.)

The previously described Radiologically Restricted Area (RRA) was radiologically released for unrestricted use. To assure compliance with non-radioactive environmental monitoring issues, the land was deeded with restrictive covenants against excavating basements or drilling wells for drinking or irrigation water. (See also, Sections 8.2 and 8.6.13.) After the DOE transports all the stored spent fuel and GTCC from the ISFSI, it will be decommissioned (as described in LTP Section 3.2).

### 8.3 PSDAR Update for Remaining Dismantlement and Decontamination Activities

The PSDAR has been updated to reflect the current status of the decommissioning, and is consistent with the LTP.

### 8.4 Update of Maine Yankee Environmental Report

This section of the LTP presents any relevant new information or significant environmental change from the MYER, as supplemented. These instances of new information or significant environmental changes are focused upon that which is relevant to Maine Yankee's proposed decommissioning/license termination activities. See Sections 8.5 and 8.6 respectively, for specific discussions on Radiological and Non-Radiological Impacts.

Any identified new information or significant environmental change associated with Maine Yankee's proposed decommissioning/license termination activities has been evaluated to determine whether it is bounded by the site-specific decommissioning activities described in Maine Yankee's PSDAR, AEC's Final Environmental Statement or the FGEIS.

#### 8.4.1 Site Location<sup>2</sup>

Section 2.1 of the MYER described the location and boundaries of the site. At the time the plant site consisted of 740 acres. In 1995, Maine Yankee purchased an additional 80 acres of land from US Gypsum. This additional land had historically been used for coastal farming and as a private residence prior to being purchased by the utility. This land has remained non-impacted by plant operations.

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<sup>2</sup> The original section titles of the MY Environmental Report are used in this LTP section and the most convenient means to organize the "update" information. Each section's content was expanded, as needed, to accommodate the updated information. For example, Section 8.4.1's content was expanded beyond "Site Location" to include changes in the site boundary, construction projects subsequent to plant construction, and to summarize site demolition and decommissioning activities.

Section 9 of the MYER described the long-term effects of plant construction, including, among other things, the availability of property to the public for recreational and educational purposes.

On January 3, 2001, Maine Yankee submitted an application to amend the license to release a portion of non-impacted land, West of the facility, from the jurisdiction of the license. The recently purchased land was included within land proposed for release. The proposed release of the lands will facilitate the donation of this property to an environmental organization pursuant to a FERC-approved settlement agreement. The purpose of the donation is to create a nature preserve and an environmental education center and to provide public access of coastal lands in the mid-coast region of Maine. This purpose is consistent with the long term use of the property envisioned in the MYER.

On April 10, 2001, Maine Yankee submitted a second application to amend the license to release the remaining portion of non-impacted land, North of the facility, from the jurisdiction of the license. The proposed release of the lands will facilitate potential redevelopment and reuse of the land. This purpose is consistent with the long term use of the property envisioned in the MYER.

On August 16, 2001, Maine Yankee significantly revised and resubmitted its application to amend the license to release non-impacted lands, approximately 641 acres, from the jurisdiction of the license. This application combined the two previous applications into one and presented the radiological survey data and associated statistical analysis results in a more cohesive manner. The statistical analysis results were used to demonstrate that residual activity, if any, in these lands is indistinguishable from background. This application was supplemented on November 19, 2001, to address comments raised by the NRC staff. The subject license amendment was granted by the NRC on July 30, 2002 (Reference 8.9.36).

On March 15, 2004, Maine Yankee submitted letter MN-04-020 requesting an amendment to the facility operating license pursuant to 10 CFR 50.90 and in accordance with the NRC Approved LTP for Maine Yankee, to acquire NRC's approval of the release of the Non-ISFSI site land from the jurisdiction of the license. From March 2004 to July 2005, Maine Yankee submitted supporting final status survey reports, supplements to the amendment and responses to NRC requests for additional information. On September 30, 2005, NRC issued Amendment No. 172 consisting of the unrestricted release of the remaining land under License No. DPR-36, with the exception of the land where the ISFSI is located and an adjacent parcel of land. The total land area that remains within the control of the 10 CFR 50 License is approximately 12 acres.

Section 3.1 of the MYER described, in general terms, the historical arrangement of plant structures on the site.

Table 8-1  
Deleted

All site structures constructed subsequent to the original plant were located on areas of the plant site that were disturbed during plant construction with the exception of the addition of the west forebay dike and diffuser piping. These latter two structures were contemplated in the MYER as part of several alternatives discussed that were available if needed to reduce thermal impacts on receiving waters. Maine Yankee also removed a causeway that connected with Westport Island. The causeway, constructed in 1950 across Cowseagan Narrows, was a major impediment to tidal circulation in the Back River/Montsweag Bay in the area of the plant. Removal of the causeway, coupled with the installation of a submerged multiport diffuser, eliminated localized adverse thermal impacts from surface discharge to Bailey Cove.

Several structures were constructed as part of the ongoing decommissioning at Maine Yankee. Two temporary solid waste storage areas were permitted with MDEP and constructed. These two areas were available for the temporary storage of concrete debris from decommissioning prior to shipment offsite. Closure of these two areas was in accordance with the Maine Solid Waste Management Rules.

In addition, Maine Yankee constructed an Independent Spent Fuel Storage Installation (ISFSI) for the onsite storage of used nuclear fuel. Decommissioning of the ISFSI is discussed in Section 3 of the LTP.

The decontamination/dismantlement of the remaining structures associated with the ISFSI will not alter the anticipated impacts of decommissioning. Impacts will be typical of those associated with demolition of structures and include erosion and sedimentation, fugitive dust emissions, noise, transportation of wastes and disposal of wastes.

Decontamination/dismantlement of the forebay/diffuser piping as discussed in Section 3 resulted in short-term mitigable and unavoidable impacts to marine resources. Decommissioning activities were timed (in consultation with regulatory agencies) to avoid periods when migratory species could be adversely impacted. Activities that occurred within the intertidal zone were of short duration.

The decommissioning, including decontamination and dismantlement, of these structures is described in LTP Section 3.

#### 8.4.2 Climate

Section 2.6 of the MYER describes climatology and meteorology of the site. At the time of the submittal of the original version of the LTP, Maine Yankee had



collected twenty-five years of additional meteorological data. Much of this data has been submitted to the NRC in the annual (formerly semi-annual) effluent and environmental reports. As might be expected, there has been no significant change in climatology or meteorology.

#### 8.4.3 Demography

Section 2.1 of the MYER described the population of Wiscasset and six other population centers. The following table updates this information with respect to the US Census Bureau 1999 population estimates for these same locations. While the populations of the town of Wiscasset and the two closest population centers have grown modestly, the other larger population centers have not.

<b>Table 8-2 Wiscasset and Other City Population Updates</b>			
<b>Location</b>	<b>1970 Population (Ref.1972 MYER)</b>	<b>1999 Population Est. (US Census Bureau)</b>	<b>Distance from Plant (miles)</b>
Wiscasset	2,250	3,229	-
Bath	9,700	9,829	7
Brunswick	16,200	20,899	14
Augusta	22,000	19,722	27
Lewiston - Auburn	65,900	58,660	29
Portland	65,100	61,925	38
Bangor	33,200	32,662	75

MYER Section 2.2 describes the population density and population totals within a 5 mile radius of the plant and describes the general area. The area surrounding the plant remains rural. It currently has relatively low population density of approximately 90 per square mile within 10 miles of the plant. The population is higher at distances of 30-40 miles (with a slightly lower density in the area between 10 and 20 miles). At 40-50 miles out the population density drops.

The population of the two nearest cities (Lewiston, 36,193 and Auburn, 22,467) are significantly less than the FGEIS model large city population of 64,000 within 29 miles.

The FGEIS evaluation considers the closest large city at about 30 miles away with a population of 1,800,000. There are no large cities (population >1 million) within 100 miles of the Maine Yankee site. The Maine State 2000 population was

1.27 million (1,274,923) and the Boston Metro Statistical Area 1990 census population was 4,171,747.

The FGEIS assumes the total population in a radius of 50 miles at 3.52 million, whereas the total population within 50 miles of MY is approximately 650,000.

This difference between the MY site and the generic site does not affect the conclusions of the environmental statement.

#### 8.4.4 Socioeconomic Data

The number of workers on site at any time is comparable to that when Maine Yankee was in operation, and will be much less than during the initial construction period. It appears that the peak work force on site during final operations was approximately 450 (MY Human Resources Dept.) and during construction was approximately 1300 (1280 - CMP weekly project report week of 6/25/71, a 1338 man peak was estimated in the June 1971 - 1972 Environmental Report (Pg 4-2)).

MY's property taxes from the operation of the plant had a positive impact on the Town of Wiscasset. The reduction in taxes concurrent with the decommissioning of the plant has had a significant impact on the town budget planning based on operating plant tax base, however MY negotiated a phased reduction of the taxes to minimize the financial impact on the town. Once the site is given unrestricted use release, the property has the potential of being developed as an industrial park which would potentially increase the local tax revenue.

#### 8.4.5 Land Use

MYER Section 2.2 describes the setting of the Maine Yankee site and surrounding environs. The plant area is characterized by home sites, summer home sites, idle farmland, forest, and small commercial establishments. The effects of plant construction and operation are described in Section 5.4 of the MYER.

Since plant construction, the overall character of the area has changed little. While additional private homes have been built near the plant in both Wiscasset and nearby Westport Island, the character of the area remains rural. Considerable commercial development has occurred along the Route 1 corridor located two miles northwest of the site.

As part of a FERC rate case settlement, a 200 acre portion of the plant site was donated to the Chewonki foundation for environmental education purposes. This will continue to provide public access to this parcel which has been allowed during plant operation. Remaining portions of the site will, following license termination, become available for redevelopment.

The small percentage of land used for farming, combined with the low population density, and the commitment to continued application of radiation protection and contamination controls during decommissioning, results in radiological consequences to the public lower than those calculated in the FGEIS.

Decommissioning activities are not expected to have any adverse impact on surrounding land uses both onsite and off.

#### 8.4.6 Surface Water

The surface water regime for the plant site and surrounding areas is described in detail in Section 2.5 of the MYER. Plant operation impacted surface water in two areas. First, fresh water for sanitary uses, plant make-up, and fire protection was piped to the plant from a reservoir located on Montsweag Brook, two miles northwest of the plant. Once through cooling water was provided from the Back River. Potable water for the plant was provided by an onsite bedrock well. Two additional wells supplied water for the Bailey farmhouse and Eaton farmhouse domestic needs.

Since plant start-up, there have been several changes to surface water use by the plant. In the early 1970's, in coordination with federal and state environmental agencies, several alternatives previously considered in the MYER were implemented to reduce the thermal impacts of the plant on the Back River and Montsweag Bay. Maine Yankee removed the Cowseagan causeway and replaced it with a bridge. This change, discussed in Section 8.4.8 of the MYER, increased the tidal flushing and flow in the Back River. In addition, the west forebay dike was constructed and diffuser piping was installed beneath Foxbird Island that discharged in the Back River channel. These changes helped restore the Back River to its pre-causeway condition and mitigated impacts of the plant's thermal discharge.

In the early 1990's, changes to the federal Safe Drinking Water Act triggered an evaluation of the plant's fresh water supply. The decision was made to connect with the Wiscasset Water District to supply all domestic and drinking water needs for the plant. Use of the bedrock well was then discontinued. Water from Montsweag Brook continued to be used for fire protection and plant make-up through operation. The Montsweag Brook dam and pumphouse were removed. All plant freshwater needs are met by the Wiscasset Water District. The Bailey farmhouse and Eaton farmhouse wells were utilized for a period during decommissioning of the Plant. These wells are now abandoned.

The cooling water system (including the service water system) was originally used for the dissipation of heat and the discharge of domestic wastes and conventional pollutants. The cooling water system was decommissioned.

In the early 1990's, continued problems with the onsite sanitary waste treatment plant resulted in connection of the plant site to the Wiscasset sewer system. At that time, discharge of sanitary wastes from the treatment plant ceased.

Surface water use during decommissioning will be considerably reduced from operational conditions. The demand will be for domestic uses and will certainly be less than during plant operation.

#### 8.4.7 Groundwater

Section 2.5 of the MYER states:

“Groundwater in the region occurs as free groundwater within the clay-silt soil mantle and joints in the underlying bedrock.....Precipitation at the power station site will percolate downward to the water table and then move with the normal groundwater flows toward the adjoining salt water areas. Percolation rates however, are low due to the low permeability of the local soils and limited bedrock jointing.... Water wells in areas adjacent to the site are either dug wells, usually less than 25 feet deep, or drilled wells penetrating the bedrock for depths of 100 feet or more. Such wells are for domestic or farm use. Although adequate for the purpose, their yield seldom exceeds 5-10 gallons per minute for short term pumping and even less for sustained pumping. There are no municipal or other important well water supply systems in the area” (Reference 8.9.2, 2.5-1)

Section 9 of the MYER states:

“During its operation the Maine Yankee plant will not affect the water it uses so that the water would be unfit for use by others.”

In addition to the pre-operation construction associated with the Bailey Point area, numerous subsurface exploration studies were conducted over the years of operation at the facility. A description of the site may be found in other Maine Yankee documents including the report, “Summary of Geologic Information Covering the Maine Yankee Nuclear Power Plant Site and Vicinity” (Reference 8.9.15).

The discussion regarding groundwater across the site is retained to establish the groundwater impacts associated with the areas that remain within the control of the 10 CFR 50 License (i.e., those associated with the ISFSI and a parcel adjacent to the ISFSI). The groundwater regime at the Maine Yankee facility is comprised of two aquifers: (1) a discontinuous surficial aquifer in the unconsolidated

glaciomarine soils and fill material; and (2) a bedrock aquifer. The surficial aquifer is not present continuously across the site, as the overburden soils are thin to non-existent in some portions of the site. This is especially true in the southern portion of Bailey Point. The bedrock aquifer is present below the entire site and vicinity.

To summarize the hydraulic regime at the site, a discussion of a previously developed groundwater flow model is presented below. A three-dimensional groundwater flow and transport model of Bailey Point has been developed.<sup>3</sup> This model allows an evaluation of flow paths, travel times, and dilution of contaminants from their source locations in the model.

The modeling of the transport of solutes introduced into the groundwater at the Maine Yankee site was developed using the MODFLOW three-dimensional flow model and the MT3D transport model. There has been no attempt to model unsaturated flow and transport. It is expected that unsaturated flow through a 10-foot thick section of soil (the permanent water table is typically about 10 feet down in thick soils at the site) would take on the order of weeks. The model extends from Old Ferry Road to the end of the peninsula to the south. This is a four to five layer bedrock and saturated soil model with varying grid sizes. The southern portion of the model has four bedrock layers and a 20-foot grid square spacing. From the Administration Building north to Old Ferry Road, five layers are included in the model, as saturated soils occur in this portion of the site. The soil thickness in this area can be significant and there is much saturated soil, so the inclusion of the soil, where it occurs, is important. Some of this soil is glaciomarine clay-silt. Where saturated soil occurs, it is modeled as either one or two layers depending on the expected water table position and type and thickness of soil. Cell sizes in the northern area of the model are 50 feet by 50 feet horizontally. The bottom of the model is 700 feet below top of rock. The bedrock is treated anisotropically such that the transmissivity in the north-south direction is 5 times greater than in the east-west direction.

For solute transport problems involving years of application of a solute at a relatively steady rate, the average annual recharge rate is used. For the northern portion of the model, this is 30 percent of average annual precipitation since most of the area has thick soil cover (which is included in the model). For the southern portion of the model (which is basically a bedrock model), the recharge rate is set at 10 percent of average annual precipitation, with the rest being runoff and evaporation. Depending on the aquifer thickness, porosity and recharge rate, there is a certain amount of time required for a "conservative" solute (one not removed by adsorption, precipitation, radioactive or biological decay, volatilization or

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<sup>3</sup> For additional information of the subject groundwater model, see Chapter 5 of the QAPP, Reference 8.9.24.

otherwise) to reach a steady state distribution in a defined aquifer area. Multiple time plots of concentration were checked to see how close the model is to a steady state condition. For the northern model area, steady state is close after 20 years of simulation; for the southern model area, steady state is reached by 10 years.

The near-surface flow in the saturated soil under the ISFSI area is northwestward, but the head contours suggest the ISFSI area is on a groundwater divide with flow going both northwest and southeast. Travel times from the surface of the ISFSI area to Montsweag Bay discharge points are on the order of 10 years or more because of the relatively thick, low permeability soil under the ISFSI area.

Groundwater originating near the surface in the northern portion of the model area generally moves vertically into the soil except in the wetland areas where groundwater discharge locally occurs. After slow movement through the soil, the groundwater moves into the deeper bedrock and travels toward the bay, discharging upward in the near-shore area. In the southern portion of the model, groundwater originating near ground surface generally stays near the surface, rather than penetrating deep into the bedrock. Movement through the bedrock is expected to be fairly fast because of the low porosity of the rock. Conservative contaminants move through the rock included in the southern model area to shallow discharge areas in a time frame on the order of several hundred days as demonstrated by a 1989 study of a sodium chromate leak in the area south of the Containment Building (Reference 8.9.13).

Measured seasonal changes in groundwater elevations in the area north of Old Ferry Road near in the area of the once-proposed coal ash disposal area. These results demonstrate seasonal changes in the historic on-site wells of two to four feet for most wells, with up to 10 feet north of Old Ferry Road, where topographic relief is greatest.

Groundwater chemistry of the bedrock aquifer is documented by the Maine Department of Human Services (MDHS) well water test results of the plant well, the Eaton Farm well, and the Bailey Farm well for the period 1988-1995. Groundwater quality in the immediate vicinity of the plant structures is summarized in groundwater monitoring studies conducted by Robert G. Gerber, Inc. (Reference 8.9.16).

Groundwater flow and chemistry in the southern portion of the model area was influenced by the presence of the Containment foundation drain sump at 47' below mean sea level (MSL) under the reactor and 14 feet below MSL under the remainder of the Containment Building. This has induced a very localized flow toward the Containment Building and induced some seawater intrusion into the sump (up to 10 percent dilute seawater). The granular backfill around buried piping and storm drains also allowed sea water to flow backward from the diffuser

forebay into the yard area during times of spring high tides and during plant operation. Previously, during plant operation, the forebay water levels were 5 feet higher than present due to the consistent discharge of 420,000 gallons per minute.

The Maine Yankee plant operated for approximately 26 years (1972-1997). Over that time, minor spills and releases have occurred (primarily petroleum) as well as a few significant releases. These spills and releases are summarized in the MDEP RCRA Facility Assessment (RFA) (Reference 8.9.19) and the Site Historical Report (Reference 8.9.20). Four significant releases have occurred over the years of operation including: (1) a release of an unknown amount of chromated water from the Primary Component Cooling system to a storm drain in October 1985; (2) a release of approximately 12,000 gallons of de-mineralized water containing sodium chromate in December 1988 (Reference 8.9.13 and 8.9.14); (3) an accidental release of approximately 200 gallons of low viscosity transformer oil to the Back River in May 1991; and (4) a release of kerosene to subsurface soils in the former Spare Generator Storage Building adjacent to the west side of the ISFSI area in June 1994 (Reference 8.9.17 and 8.9.18). These four releases have been studied and remediated to the satisfaction of MDEP.

In addition to the known spills and releases, the GTS Duratek Characterization Survey Report (Reference 8.9.21) has provided additional understanding concerning the distribution of environmental contamination at the Maine Yankee facility. The GTS Duratek study included water, soil, sediment, and groundwater samples from potential areas of concern including historic spills and releases, outfalls, and catch basins. The samples were typically analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), metals, polychlorinated biphenyls (PCBs), and diesel range organics (DRO); however all compounds were not analyzed in each sample.

Groundwater samples were taken as part of the GTS Duratek study from existing monitoring wells located in the southern portion of Bailey Point. This portion of the facility was the locus of the significant industrial activity and the results for VOCs, SVOCs and metals demonstrate that groundwater quality has not been significantly impacted by the long-term industrial activities at the site.

Aside from the localized flow into the Containment Building foundation drain sump, groundwater in the industrial portion of Bailey Point flows in a quasi-radial direction towards Bailey Cove to the west, Back River to the east and the Montsweag Bay to the south. Thus any contaminants dissolved in groundwater will flow into those surface water bodies.

During plant operation, impacts to the groundwater flow regime were limited to localized draw down of the groundwater surface caused by foundation drains around the containment structure and to a lesser extent draw down by active water

supply wells. The containment structure was dismantled to 3-feet below grade and backfilled. Thus, groundwater levels are expected to recover to approximate pre-construction levels.

In response to NRC requests for additional information during the LTP review process, Maine Yankee provided an updated, comprehensive site hydrogeological report (Reference 8.9.29). Based on that report (and subsequent discussions with the NRC), an additional round of groundwater well samples were obtained and analyzed on-site by Maine Yankee with selected well samples also analyzed off-site by a vendor laboratory, the State of Maine, and by the NRC. The Maine Yankee assessment of these results, which generally confirmed low levels of tritium in site groundwater, is provided in Section 2.

Dose calculation modeling for the LTP resident farmer scenario addressed in Sections 2 and 6 have included use of this slightly contaminated groundwater for domestic purposes and demonstrated that this level of groundwater contamination would not limit future site use.

#### 8.4.8 Biota

Section 2.7 of the MYER provides an overview of biological resources found at the Maine Yankee site.

The coastline around the site varies between salt marsh and mud flat with some rocky areas where the gradient is steepest. The salt marsh vegetation is dominated by *Spartina patens* and *Spartina alterniflora* which are both obligate wetland species. Where rocky substrate is present, seaweed is also prevalent in the intertidal zone. The mud flats are generally devoid of vegetation with the exception of salt marsh species along the edge. Mud flats are typically found in areas that are slightly sheltered such as small coves. Landward of the salt marsh and mud flat areas, the coast has a steep incline up to the upland areas, which are dominated by trees such as white pine (*Pinus strobus*) and red oak.

“Land animals inhabiting the site include deer, racoons, and smaller mammals. Non-poisonous snakes can be found. ... The bird population varies greatly between seasons and between periods of migration and residency....” (Reference 8.9.2, Pg 2.7-1).

Section 9 of the MYER (pg. 9-1) describes the long-term effects of plant construction, including, among other things, the effect of plant operational heat dissipation on the estuarial system. It states:

“As long as the plant is operated so that the temperature of the discharge is below a damaging temperature for any ecologically important species, there



should be no cumulative effect on the river system. If the plant were to be permanently shutdown, repopulation of any disturbed inter-tidal areas by water-borne larva would soon occur.”

Since plant construction, areas of the site disturbed by construction activities have stabilized and revegetated. Mowed areas are dominated by native and exotic grasses and herbaceous species. Unmowed areas have now been colonized by pioneer species such as poplar, white birch and shrubs. Some of these areas will be redisturbed by decommissioning; however, the total area disturbed will be smaller than during plant construction. Mature pines and oaks located along the perimeter shoreline were largely undisturbed by plant construction and operation and those remaining will not be disturbed by decommissioning activities. Following decommissioning, virtually the entire site will be revegetated.

Throughout Maine Yankee’s operating history, onsite sightings of wildlife have been common with red fox, raccoon, white-tailed deer, and other small mammals observed frequently. Protected status and elimination of persistent pesticides from the environment has contributed to a dramatic increase in the population of osprey along the eastern seaboard. Seasonally active osprey nests are located on plant property in the immediate vicinity of the plant. The osprey are not affected by plant activities and have been observed attempting to build nests on active equipment. Bald eagles are also observed in the plant area but no known nesting sites occur on plant property.

Marine species are discussed in Section 2.7 of the MYER. Since plant construction there have been two notable changes in marine biota adjacent to the plant site. First, removal of the Cowseagan causeway significantly improved the circulation of the Back River. As a result, the area has seen an increase in lobster populations and the Back River now supports commercial lobster fishing. Second, management of the striped bass fishery along the eastern seaboard has resulted in a dramatic increase in the numbers of this popular game fish. While commercial fishing for striped bass is not allowed in Maine, recreational fishing is growing in popularity and the Back River is used by recreational fishermen.

Decommissioning of shoreline structures has the potential to have impacts on marine habitats and biota. Impacts may include disturbance of substrate, sedimentation and turbidity. Careful project planning, consultation with regulatory and resources agencies, and permitting requirements will serve to minimize the duration and extent of these impacts. Following disturbances, affected areas are expected to recolonize quickly. See additional discussion on the evaluation for impact related to the decommissioning of shoreline structures (under the NRPA process) in Sections 8.2 and 8.6.4.

#### 8.4.9 Water Use

Section 2.5 of the MYER states:

“Water wells in areas adjacent to the site are either dug wells, usually less than 25 feet deep, or drilled wells penetrating the bedrock for depths of 100 feet or more. Such wells are for domestic or farm use. Although adequate for the purpose, their yield seldom exceeds 5-10 gallons per minute for short term pumping and even less for sustained pumping. There are no municipal or other important well water supply systems in the area.” (Reference 8.9.2).

Section 8.4.6 outlines the sources of water used at Maine Yankee and describes changes that have occurred since plant start up.

Potable water usage (from the Wiscasset Water district) during decommissioning is summarized in Table 8.3. Based on the average monthly use for the first three years of decommissioning, total water use for decommissioning the Maine Yankee Nuclear Plant was projected at 2.3 million cubic feet (17,385,000 gallons). Additional minor amounts of water from Montsweag Brook were also used early in decommissioning prior to abandonment of that source. The use of water during decommissioning of the Maine Yankee Nuclear Plant was minor compared to the use of water during operations. In addition, the use of potable water during the period of storage of spent fuel and GTCC waste at the ISFSI and the decommissioning of the ISFSI will be minor compared to the use of water during operations or during decommission of the Maine Yankee Nuclear Plant.

Maine Yankee was connected to the Wiscasset Water District to provide potable water and sewage service to support plant operations in October of 1995. For the last quarter of 1995, Maine Yankee used 73,000 ft<sup>3</sup> of water, in 1996 the plant used 235,300 ft<sup>3</sup> of water, and for the first seven months of 1997 before cessation of operations, the plant used 211,500 ft<sup>3</sup> of water. Before the plant was connected to the Wiscasset Water District, water to support plant operations was obtained from wells on site. Records of water usage from the wells during operations were not maintained.

The FGEIS makes the conclusion that the environmental consequences of decommissioning, including the use of water, are minor compared to the environmental consequences of building and operating the plant. For the generic plant, an operation water usage of 953 million cubic feet of water per year is compared to a total decommissioning usage of 636 thousand cubic feet (4.76 million gallons) of water. While Maine Yankee's estimated water usage of 17 million gallons is greater than the 4.76 million gallons anticipated based on the

FGEIS generic plant, it is much less than the amount used during operation and the amount used by the generic plant in operation. Therefore, the FGEIS conclusion that the environmental consequences of the decommissioning use of water is minor compared to the environmental consequences of building and operating a nuclear plant is valid for Maine Yankee.

<b>Table 8-3</b> <b>Maine Yankee Decommissioning Water Use</b> (Expressed in hundreds of ft <sup>3</sup> )													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1998	609	1004	483	464	182	426	248	620	236	422	108	88	4890
1999	100	77	100	116	94	252	188	143	194	206	294	121	1885
2000	131	128	320	152	152	215	303	167	897	436	143	142	3186
Annual Average Usage 332,033 ft <sup>3</sup> (2,483,609 gallons)													
Monthly Average Usage 27,700 ft <sup>3</sup> (207,196 gallons)													

The Wiscasset Water District has advised Maine Yankee that continuing to supply this volume of water will not adversely affect the District's water supply or their ability to provide the required volume to the site.

#### 8.4.10 Effects of Decommissioning

Section 9 of the MYER (pg. 9-1) describes the long-term effects of plant construction, including, among other things, the restoration of the site following permanent shutdown. It states the following:

"If a time were reached when the site was no longer required for electrical production, the plant could be dismantled and completely removed from the site. Grading and landscaping could restore the plant area to natural cover. By using special dismantling procedures all components of the plant could be removed for disposal in approved burial grounds. Since no radioactive material is disposed of on site, this would leave the site radioactivity level at or very close to the background level for the area and suitable for other use."

Section VIII of the AEC Final Environmental Statement for Maine Yankee describes the decommissioning of Maine Yankee. It states the following:

“Upon termination of use of the power station the Plant can be decommissioned and the site converted to initial uses or used for other industrial and recreational activities. Decommissioning would involve removing and reclaiming fuel, decontaminating and “fixing” accessible surfaces of radioactivity, removal of salvageable equipment, and sealing of the reactor and components. The degree of dismantlement, as with most abandoned industrial plants, would be contingent on a balance of health and safety considerations, salvage values, and environmental impact as judged by the knowledge and technology developed in future years.”

The dismantlement plan described in LTP Section 3, details the dismantlement of the plant systems and structures. These details compare well with the original decommissioning vision described above in the MYER and the AEC Final Environmental Statement. Radioactive material will be cleaned up to meet the radiological criteria of 10 CFR Part 20, Subpart E and the enhanced state cleanup standards. Following decommissioning of the ISFSI, Maine Yankee plans to release the site for unrestricted use.

#### 8.4.11 Historical and Archeological Resources

Section 2.3 of the MYER provides an overview of the historical resources in the plant vicinity. The MYER does not discuss archaeological resources.

Through consultation with the Maine State Historic Preservation Office (SHPO) in 1991, two minor archaeological sites (16.212 & 16.213) were identified on Maine Yankee property within several hundred yards of the plant. Both sites are located immediately adjacent to the shoreline in areas that were undisturbed during plant construction. The SHPO was contacted in conjunction with decommissioning and has not identified any additional cultural sites on Maine Yankee property.

Because of their locations, the two known archaeological sites will not be disturbed or impacted during decommissioning.

On October 10, 2001, Maine Yankee transmitted to the SHPO a copy of the Maine Yankee Comprehensive Natural Resources Protection Act Application (Reference 8.9.25), which covered the balance of the planned construction and demolition activities within 100 feet of protected natural resources that are associated with the decommissioning of its nuclear power facility. These construction and demolition activities included: the cooling water discharge structures, forebay, diffuser piping, remediation activities, demolition of the Bailey Farm House, Information Center, fire pond, warehouse, and other minor structures.

On October 25, 2001, the SHPO responded to Maine Yankee (Reference 8.9.35). The SHPO stated: "Our office feels that the subject property and area of potential effects does not contain resources eligible for listing in the National Register of Historic Places." Therefore, the SHPO found no historic properties (historic, architectural or archaeological) affected by this project

#### 8.4.12 Endangered or Threatened Species

Section 2.7 of the MYER discusses plant and animal life at the Maine Yankee site. At that time there were no identified endangered species as the Endangered Species Act (ESA) was passed in 1973.

In permitting structures constructed after plant start up through the Maine Site Location of Development Permit process, Maine Yankee has consulted with federal and state resource agencies to identify rare and endangered species. These agencies have also been consulted in conjunction with decommissioning.

In response to Maine Yankee's inquiry, the U.S. Fish and Wildlife Service (USF&WS) identified only two federally listed species under their jurisdiction. The bald eagle (*Haliaeetus leucocephalus*) and peregrine falcon (*Falco peregrinus*) are both identified as transient species (Reference 8.9.38).

The National Marine Fisheries Service (NMFS) identified the shortnose sturgeon as known to occur in the Back River and Montsweag Bay, especially during the summer months (Reference 8.9.39). Subsequent to receipt of the NMFS letter, the Atlantic salmon (*Salmo salar*) was listed as endangered species (Federal Register 11/17/00).

Decommissioning of shoreline structures had the potential to have impacts on marine habitats and biota. Impacts may include disturbance of substrate, sedimentation and turbidity. Careful project planning, consultation with regulatory and resources agencies, and permitting requirements served to minimize the duration and extent of these impacts. No adverse impacts on rare and endangered species are expected. Maine Yankee's assessment of this impact and the review by State and Federal agencies were accomplished under the NRPA process. Impact to marine resources from decommissioning activities was evaluated in the Maine Yankee applications for permit under the NRPA (MN-02-012, References 8.9.30 and MN-02-030, Reference 8.9.31) for that work accomplished at or near the shoreline, per State of Maine requirements. The principal work subject to the NRPA process included the demolition and restoration of the circulating water pump house and the sewage treatment plant and the characterization, remediation, and decommissioning of the forebay/diffuser system. The evaluation and

permitting conclusions by Maine Yankee and State/Federal agencies are described in Section 8.6.4.

#### 8.4.13 Environmental Effects of Accidents and Decommissioning Events

The MYER considered the radiological impacts on the environment of various classes of accidents. These classes ranged from Class 2 events to Class 8. The events discussed are listed in Table 8-4 below:

<b>Table 8-4</b> <b>Environmental Impacts of Accident Classes</b>		
<b>Event Classification</b>	<b>Classification Description</b>	<b>Event Description</b>
2	Small Releases Outside Containment	a. Leakage from Valves and Mechanical Seals
		b. Cracked Pipe in Chemical Volume Control System
3	RadWaste System Failures	a. Gaseous Radwaste
		b. Liquid Radwaste
4	Events that Release Radioactivity Into the Primary System	Not Applicable
5	Radioactivity Release Into Secondary System	a. Steam Generator Tube Leakage
		b. Steam Generator Tube Rupture
6	Refueling Accidents Inside Containment	a. Fuel Assembly Drop
7	Fuel Handling Accidents Outside Containment	a. Cask Drop
		b. Fuel Assembly Drop
8	Accidents Initiated by Events Considered in the FSAR	a. Main Steam Line Break
		b. Control Element Assembly Ejection
		c. Loss of Coolant Accident

On August 7, 1997, Maine Yankee submitted its certification of permanent cessation of operation and permanent fuel removal from the reactor in accordance

with 10 CFR 50.82(a)(1). The spent fuel and GTCC waste have been transferred to the ISFSI, and the decommissioning of the plant (with the exception of those activities associated with the ISFSI) is complete. Thus, the above event classifications no longer apply.

There are no postulated events or accidents associated with the ISFSI that could result in radiological consequences.

## 8.5 Radiological Environmental Impacts

### 8.5.1 Radiological Criteria for License Termination

Maine Yankee will comply with the enhanced state cleanup standards contained in Maine State Law LD 38MSRA§1455. These standards specify a residual dose limit of 10 mrem/yr total with a groundwater contribution not to exceed 4 mrem/yr. These requirements are less than 40 % of the NRC's 25 mrem/yr all pathway exposure limit.

### 8.5.2 Decommissioning versus Plant Operation

The radiological effluent releases and direct exposures to the hypothetical maximally-exposed individual from decommissioning activities are expected to be comparable to or below those experienced by the maximally-exposed individual during operations. Table 8-5 provides a comparison of the maximum annual total body dose commitments reported in Annual Dose Reports during the operational period (1995 and 1996) versus the decommissioning period (Post 1996). The table is divided into three pathway categories Direct External, Liquid and Gases.

<b>Table 8-5</b>					
<b>Maximum Annual Total Body Dose Commitment (mrem)</b>					
	Operational Period		Decommissioning Period		
Pathway	1995	1996	1997	1998	1999
Direct External	3.5	1.5	0.84	1.3	1.5
Liquid	0.021	0.002	0.0056	0.012	0.0015
Gaseous	0.0034	0.000013	0.000086	0.00012	0.0053
Total	3.5	1.5	0.85	1.3	1.5

Other radiological impacts of decommissioning Maine Yankee are discussed in Sections 8.3, 8.4 and 8.7.

## 8.6 Non-Radiological Environmental Impacts

### 8.6.1 Overview of Other Regulators Covering Site Release

In addition to involvement by the NRC, the decommissioning of Maine Yankee involves coordination with a number of federal, state and local agencies as well as several advisory groups. Sections 3.6.1 and 3.6.2 discuss the primary functions, programs, and regulatory authority of these agencies and advisory groups.

### 8.6.2 RCRA Closure Process

Resource Conservation and Recovery Act (RCRA) - RCRA as applied to Maine Yankee decommissioning pertains to the "closure" of the site with respect to chemical contamination. RCRA closure is required for the Maine Yankee site because Maine Yankee was a large quantity generator of hazardous waste, has documented historical spills and because Maine Yankee temporarily held a RCRA Part A interim license in the early 1980s with final closure deferred until decommissioning. MDEP has been designated as the lead agency for RCRA closure activities at Maine Yankee with technical support being provided by EPA.

The closure process involves a rigorous examination of site history, investigation (including sampling) of the site, evaluation of analytical results against risk-based standards, and possibly remediation if determined necessary to protect human health and the environment. The closure process includes ample opportunity for public input; for example, a public information meeting was held June 12, 2000, a public presentation of the RCRA Sampling Program was given on May 23, 2001, and an internet web site: [www.state.me.us/dep/rwm/myankee/homepage.shtm](http://www.state.me.us/dep/rwm/myankee/homepage.shtm) is maintained by MDEP. Additional public information meetings will be held throughout the closure process.

In 1998 GTS Duratek, Inc. conducted a preliminary radiological and chemical characterization of the site to determine the nature and extent of contamination (if any) for use by potential bidders on the decommissioning project (Reference 8.9.21).

Subsequent to the Duratek report and in response to MDEP's questions, a Site History Report (SHR) was written by Stone & Webster, an engineering firm then under contract to Maine Yankee, to serve as input for the closure plan that Maine Yankee, as a generator of hazardous waste, will prepare to meet the requirements of the Standards for Generators of Hazardous Waste [06-096-CMR 851(11)]. The report did not address all closure issues, since it did not deal with the characterization of the waste generated by the demolition of buildings and any soil



underneath or adjacent to those buildings. To address potential releases to the environment from the buildings, a visual site assessment was performed in November 2000 and submitted to State regulators (Reference 8.9.22). The SHR and visual site assessment were used to prepare a RCRA Quality Assurance Project Plan (QAPP) submitted to the MDEP for review in February 2001.

The SHR provided the MDEP with a detailed summary of past or present known hazardous material releases or spills of any significance, Maine Yankee's response to those releases, and the current status of any impacted areas of the facility. Additional spills and releases that were not required to be reported to MDEP or the U.S. Coast Guard were identified by a review of other available records, including operating logs dating back to the beginning of operations at the facility, site inspections, and interviews of past and present employees, and are also addressed.

In broad terms, the RCRA closure process generally parallels the characterization, dose assessment, remediation, and Final Status Survey steps involved in the LTP process. (See Table F.1 of MARSSIM, NUREG-1575 for a more detailed comparison of the LTP and RCRA processes.)

The QAPP defined the extent of additional investigations required to adequately characterize the potential chemical contamination at the site, for all media to remain following decommissioning. The QAPP included development of a three dimensional groundwater model used to assess fate and transport of contaminants, an Ecological Risk Assessment Plan, and proposed sampling and analytical activities. The QAPP followed the latest EPA guidelines to ensure that data quality objectives (DQOs) are met for the project.

The RCRA QAPP (Reference 8.9.24), which outlined the RCRA Facility Investigation (RFI) plan, was provided to the State of Maine for review and comment in February 2001. A public meeting was also held to provide opportunity for public input into the process and, specifically, on the QAPP. Maine Yankee has completed the initial phase of the RFI, that is, the collection of non-radiological soil, sediment, groundwater, and other site material samples to support RCRA closure in accordance with the QAPP. This initial phase of the field investigation began in September 2001 following conditional approval of the QAPP by MDEP. The QAPP received final approval on December 11, 2001. The QAPP (with the exception of figures and other selected attachments) was submitted to the NRC by Maine Yankee letter dated, February 14, 2002 (Reference 8.9.28).

The QAPP includes a sampling and analysis plan based on a review of the site history and various building assessments. These results served to identify "study" areas which are the focus of the RFI sampling activities. The RFI sampling program

for each study area is outlined in Section 8 of the QAPP.

Following collection of environmental samples, analysis and data validation, the results were used to evaluate the risk to human health and the environment. Areas of chemical contamination that required remediation or long-term monitoring were identified based on the risk assessments. Institutional controls, if necessary, were evaluated as part of the risk assessments.

A Corrective Measures Study was prepared following completion of the RFI and subsequent RFI report. This report evaluated remedial alternatives, as appropriate, and involved MDEP review, as well as public participation. In addition, remedial activities performed as part of the Corrective Measures Implementation phase were coordinated with final site restoration plans and MDEP permits (i.e., NRPA and Site Law) and approvals, as applicable, to ensure protection of public health and the environment. Storm water discharge permits, erosion and sediment controls, fugitive dust plans, etc. remained valid for remedial activities.

#### 8.6.3 Site Location of Development Act Termination or Transfer

Site Location of Development Law (Site Law) - The Site Law and its implementing regulations provide for a comprehensive evaluation of environmental and social impacts of development projects to ensure there are no unreasonable adverse impacts. The Site Law addresses stormwater management, groundwater impacts, solid waste disposal, erosion and sedimentation control, noise (specific standards), air emissions including odors, visual impacts, archaeologic and historical resources, wildlife and fisheries, unusual natural areas, financial capacity, traffic, soil suitability (bearing capacity, seismic, erodability, etc.), water supply and waste water disposal.

The original Maine Yankee plant was “grandfathered” under Maine Site Location of Development Act because plant construction was begun prior to 1970. Structures built after 1972 on the Maine Yankee site were subsequently permitted under the Site Law in 1992. All subsequent new construction has been reviewed by MDEP. As part of their review, MDEP consults with other agencies including the State Historic Preservation Office (SHPO), IF&W, critical areas program and others as needed. Two archaeologic sites have been identified on Maine Yankee property. Neither site has been impacted by plant construction or operation. Decommissioning activities will also not affect these two sites. The specific location of archaeological sites is not provided to ensure their integrity is protected.

MDEP has reviewed and approved a number of projects related to decommissioning under the Site Law including barge slip improvements, installation of a truck monitor for screening waste materials for radiological materials, construction of the

ISFSI, air cooling system for the spent fuel pool and initial demolition projects. The MDEP has determined that remaining waste disposal aspects of demolition of the Maine Yankee site does not require review under the Site Law. These decommissioning activities while temporarily disruptive, will ultimately result in a net decrease in environmental affects. Areas undisturbed by plant construction or operation will continue to be undisturbed as part of decommissioning.

#### 8.6.4 Natural Resources Protection Act (NRPA)

The NRPA requires a permit for certain activities located in, on, over a protected natural resource (includes wetlands) or adjacent to freshwater or coastal wetlands. Topics of NRPA review include impacts to significant wildlife habitat (habitat for state and federal listed rare and endangered species, deer wintering areas, waterfowl and wading bird habitats, including feeding and nesting areas, and critical spawning and nursery areas for Atlantic sea run salmon, shorebird nesting, feeding and staging areas and nesting islands), erosion and sedimentation control, protection of water supplies, scenic, aesthetic recreational or navigational uses, water flow, flooding and water quality.

MDEP has reviewed and approved a number of projects related to decommissioning under the NRPA including barge slip improvements, construction of the ISFSI and initial demolition projects. Project review under the NRPA includes coordination with other agencies by MDEP including as appropriate, DMR, U.S. Army Corps of Engineers and IF&W. Demolition of several additional structures during decommissioning (such as the circulating water pumphouse and forebay/diffuser) and final site restoration required approval by MDEP under the NRPA. Under NRPA, MDEP coordinates interactions with state agencies and the U.S. Army Corps of Engineers.

**Circulating Water Pump House (and Sewage Treatment Plant) NRPA Application, Review, and Approval.** On April 4, 2001, Maine Yankee submitted its application under NRPA for the demolition and restoration of the affected shoreline related to the decommissioning of the circulating water pump house (CWPH) intake structure and sewage treatment plant (Reference 8.9.31). The subject NRPA application included, among other documents, the following key elements: (1) a description of the CWPH (and sewage treatment plant) demolition, (2) the erosion control plan, including the description and use of silt boom/curtain to minimize the wetland disturbance, (3) copies of relevant correspondence (as of the time of application submittal) with various State and Federal agencies relevant to the application's review, (4) an analysis of various alternatives in consideration of impact to marine resources, and (5) a wetland delineation report.

In an April 2001 NRPA pre-application meeting with representatives from key State and Federal agencies involved in the review, additional information in support of the application was requested. As a result, Maine Yankee contracted with a qualified marine biologist to review previous Maine Yankee underwater inspection reports (of the CWPH intake structure) and provide an assessment of existing marine resources. The marine biologist's report concluded that the wetland and marine resources impacted by the removal and shoreline restoration of structures in the Back River did not require wetland compensation. The assessment also concluded that the "final conditions proposed in this area will provide higher value marine habitat than currently exist or existed at any time during the operation of the Maine Yankee Facility"<sup>4</sup> (Reference 8.9.31). As a result of this assessment, Maine Yankee modified its construction plans to use a larger rock as the rip rap to restore the bank of the Back River to provide an improved marine environment, allow an aesthetical match to existing shoreline, and to maintain desired structural stability (Reference 8.9.31).

On July 17, 2001, the MDEP provided conditional approval of a NRPA application for removal of the CWPH intake structure and sewage treatment plant (Reference 8.9.31). The U.S. Army Corp of Engineers (COE) similarly provided a Programmatic General Permit (PGP) for demolition of the CWPH /STP, dated September 26, 2000 (Reference 8.9.31).

The MDEP approval described the results of its coordinated review with other agencies addressing consideration of impact to water quality, habitat, and wetland. In addition, the permit addressed lease/easement requirements, review of historic properties, and measures proposed for the removal of contaminated soil. For additional detail included in and related to the CWPH NRPA permit approval, see Reference 8.9.31. The MDEP review included coordination among the following agencies, as documented in the permit approval: various divisions with MDEP, Department of Inland Fisheries and Wildlife, Department of Marine Resources, the Atlantic Salmon Commission, and the Maine Historic Preservation Commission. Several key discussions and findings are summarized below:

- a. Erosion control provisions described by Maine Yankee were reviewed and found to be adequate and, thus, no unreasonable impacts to water quality were anticipated (provided appropriate preventative measures are implemented).

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<sup>4</sup> "Marine Resources Associated with the MY Circulating Water Pump House Project," James T. Maughan, Ph.D., report dated April 11, 2001; submitted to the State of Maine, April 19, 2001; provided to the NRC by Reference 8.9.31.

- b. In regard to habitat considerations, minimum impacts to wildlife resources would be anticipated. The Maine Department of Marine Resources reviewed the application regarding impact to migrating anadromous fish. The MDEP also obtained the review of the Atlantic Salmon Commission. In consideration of Maine Yankee's proposed use of a floating debris boom with a weighted sediment control curtain to minimize risks to fish, the proposed project was acceptable provided that certain specified seasonal limitations be observed for instream work.
- c. Wetland impact were demonstrated, by Maine Yankee NRPA application, to be avoided and minimized as much as possible. MDEP documented its review and acceptance of the Maine Yankee report on the wetland's function and values. MDEP indicated its concurrence with the assessment of the marine biologist that wetland compensation was not required.

The MDEP permit, as granted, was a conditional approval with the key conditions as follows. (See Reference 8.9.31 for additional detail.) The Maine Yankee proposed work was acceptable provided that:

- (1) All necessary measures shall be taken to ensure that its activities or those of its agents do not result in measurable erosion of the soil on the site during the construction of the project covered by the project, and
- (2) Any instream work shall be performed between October 15 and December 31.

The Army COE approval (i.e., the PGP mentioned above) approved the proposed project work with the "special condition" that instream work be limited to the period of November 1<sup>5</sup> to April 1 (Reference 8.9.31) to protect the site's relevant endangered species, that is: (1) the shortnose sturgeon and (2) the Atlantic salmon. (See Section 8.4.12.) The COE PGP documented its coordinated review with the EPA, U.S. Fish and Wildlife Service, and the National Marine Fisheries Service. The COE concluded that the project as proposed would not cause more than minimal adverse effects to essential fish habitat (as identified under the Magnuson-Stevens Fisheries Conservation and Management Act), per Reference 8.9.31.

The demolition of the CWPH and sewage treatment plant and subsequent restoration of the affected shoreline was completed in 2001.

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<sup>5</sup> The Army COE special condition (in the PGP, dated June 15, 2001; provided in Reference 8.9.31) on instream work was slightly modified by a later agreement between Maine Yankee, Army COE, and MDEP, allowing a earlier (two weeks) instream work start date of October 15. The final form of the agreed upon condition is that documented in the MDEP permit approval (dated July 17, 2001; also provided in Reference 8.9.31). Thus, instream work was limited to a period of October 15 to December 31.

**Comprehensive NRPA Application.** Maine Yankee submitted a Comprehensive Natural Resources Protection Act (CNRPA) Application to MDEP on October 4, 2001 (submitted to the NRC by Reference 8.9.30). The application was developed by Maine Yankee as agreed upon with the MDEP and Army COE to provide a single, comprehensive application to address those remaining decommissioning activities subject to NRPA, i.e., decommissioning activities that are located in, on, or over any protected natural resource or is located adjacent to or within 100' of such resources. The most significant and complex project included in the CNRPA application involved the decommissioning of the forebay and diffuser system. (See also Section 8.2 for a discussion of the forebay/diffuser activities and proposed final state.) The CNRPA's scope also included storm water outfalls and the fire pond. See the referenced CNRPA application for additional detail.

The CNRPA application followed MDEP's prescribed format (as in the case of the CWPB NRPA application, described above), namely: (1) description of demolition activities, including the existing condition, the remediation process, and the intended demolition approach, (2) the erosion control program, including the use of a floating silt curtain device with oil boom to protect the wetland environment during the subject project, (3) an alternative analysis, and (4) a wetland delineation and mapping review report.

The MDEP documented its review and approval in the conditioned permit ordered on February 2, 2002 (Reference 8.9.32).<sup>6</sup> Consistent with the NRPA process, MDEP coordinated the review with numerous agencies (listed above in the CWPB NRPA review discussion). The Army COE worked with the MDEP and coordinated its review among several relevant federal agencies (also listed above). The Army COE CNRPA permit approval was dated February 20, 2002 (Reference 8.9.32). For additional detail on the Maine Yankee application and MDEP/COE permit approvals, see Reference 8.9.32.

Several key discussions and conclusions from the MDEP permit approval are summarized below:

- a. Erosion control provisions described by Maine Yankee were reviewed and found to be adequate and, thus, no unreasonable impacts to water quality were anticipated (provided appropriate preventative measures are implemented).
- b. The Department of Marine Resources (DMR) requested additional (RCRA) information to fully evaluate remediation of stormwater outfall areas. This

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<sup>6</sup> Maine Yankee included copies of the MDEP and Army COE approval documents in its response to NRC RAI. See Attachments I.C and I.D of Reference 8.9.32.

- information will be developed and communicated to DMR and MDEP as part of the RCRA closure process.<sup>7</sup>
- c. In order to minimize potential adverse impacts to migrating anadromous fish, certain restrictions on instream work were required similar to the CWPB NRPA permit approval. (The Atlantic Salmon Commission indicated no concerns regarding the proposed activities.) MDEP recognized that Maine Yankee's proposed decommissioning approach would leave the diffuser pipe in place and that minimal work is expected in the water. Therefore, no impact was anticipated on the Atlantic salmon population. MDEP concluded overall that the proposed project would not unreasonably harm any significant wildlife habitat, freshwater plant habitat, threatened or endangered plant habitat, aquatic habitat, etc. provided that certain conditions are met. (The principal conditions are summarized below.)
  - d. Maine Yankee's application indicated that the only impacted wetland area involved the stormwater outfall area remediation. MDEP concurred with Maine Yankee's assessment (Reference 8.9.32) that wetland compensation was not warranted due to the "lack of function and value loss based on the biological surveys and observations at the site."<sup>8</sup>

The MDEP permit, as granted, was a conditional approval with the key conditions as follows. (See Reference 8.9.30 for additional detail.) The Maine Yankee proposed work was acceptable provided that:

- (1) All necessary measures shall be taken to ensure that the activities described in the CNRPA application do not result in measurable erosion of the soil on the site.
- (2) Additional information will be provided to the MDEP for review and approval regarding remediation of each of the stormwater outfall areas,
- (3) A forebay remediation plan will be submitted to MDEP for review and approval prior to implementation.
- (4) Any instream work shall be performed between October 15 and April 1.

The Army COE approval (i.e., the PGP mentioned above) approved the project as proposed, finding that it would not cause more than minimal adverse impacts to

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<sup>7</sup> Condition 6, MDEP approval order, Reference 8.9.32 (Attachment I.C).

<sup>8</sup> Comprehensive NRPA Application, dated October 4, 2001, Reference 8.9.30.

essential fish habitat (as identified under the Magnuson-Stevens Fisheries Conservation and Management Act), per Reference 8.9.31. The COE PGP documented its coordinated review with the EPA, U.S. Fish and Wildlife Service, and the National Marine Fisheries Service.

As noted above, per the CNRPA permit approval, a forebay remediation plan was required. Based on further forebay remediation planning development, Maine Yankee elected to divide the overall plan into two phases. The initial phase would address, primarily, those activities necessary to further characterize the scope and extent of remediation activities for forebay related structures. The Phase I plan has been submitted to MDEP by Maine Yankee letter, dated June 6, 2002 (Reference 8.9.33) and was reviewed and accepted without concern in the MDEP letter, dated July 11, 2002 (Reference 8.9.37). A key element of the Phase I activities included an expanded forebay dike boring campaign to support remediation planning, primarily. The boring plan was provided to MDEP by the Maine Yankee letter, dated July 11, 2002 (Reference 8.9.34).<sup>9</sup> Phase II of the remediation plan was provided to MDEP by the end of 2002.

The NRC was provided a copy of Maine Yankee's Phase II remediation plan, as well as the results of MDEP's review (Reference 8.9.40).

#### 8.6.5 Solid Waste

Solid waste storage, handling and disposal are regulated by MDEP (38 M.R.S.A. §§ 1301 - 1316-M and associated regulations). As part of decommissioning activities, Maine Yankee permitted two areas for the temporary storage of cured concrete rubble (CCR) that MDEP regulated as special waste. Special Waste is a discretionary classification that MDEP applies to waste streams that may warrant special handling, transportation and disposal procedures to be protective of public health, human safety or the environment. MDEP has classified CCR at Maine Yankee as special waste because of the large volume of material that was generated during decommissioning activities.

As part of their oversight, MDEP has reviewed and approved Maine Yankee's Waste Management Plan (WMP) and associated sampling and verification procedures, which are outlined in and Operations Manual. Revisions to the WMP and procedures also require MDEP approval. The WMP and the Operations Manual also address handling and disposition of painted concrete, recyclable materials (wood and metals), characterization and other categories of solid waste that will be generated in

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<sup>9</sup> As noted in Attachment 2H (Section 2.4), the NRC will be updated on the results of the forebay dike boring program.



relatively small volumes during decommissioning. The WMP includes by reference Maine Yankee's procedures for controlling radiological materials, specifically provision for the release of materials from the site. The above grade concrete to be shipped off-site has been characterized in accordance with the MDEP-approved characterization plan and has been determined not to constitute a hazardous waste.

#### 8.6.6 Hazardous Waste and Hazardous Matter Control

Hazardous waste storage, handling and disposal are regulated by MDEP (38 M.R.S.A. §§ 1317 - 1319-Y, §§ 1401 - 1404, §§ 1601 - 1608, and §§ 1651 - 1654 and associated regulations). Included within the hazardous waste regulations is the control of mixed waste (i.e., waste that is both hazardous and radiological). In addition to MDEP, EPA also regulates PCBs under the Toxic Substances Control Act (TSCA).

As with solid waste, hazardous waste handling, storage and disposition are controlled through Maine Yankee's MDEP-approved WMP and associated procedures. The WMP and procedures address mixed waste, PCBs, lead, asbestos, mercury, and other listed and characteristic hazardous wastes. PCBs at concentrations greater than the 50 parts per million (ppm) standard have been identified at Maine Yankee in paint on some steel and concrete surfaces and in the sheathing of some electrical cables. PCBs in these areas meet the definition of Bulk Product Waste under TSCA, which allows them to be handled and disposed of at many landfills. In Maine, PCB-containing materials ( $\geq 50$ ppm) are classified as a hazardous waste and must therefore be handled, transported and disposed of accordingly.

Maine Yankee has programs in place to address active and historic spill reporting and remediation during decommissioning. The Maine Yankee Spill Program requires reporting of spills to the MDEP and other agencies as appropriate. Maine Yankee's Excavation Procedure provides guidance for identification in the field of historical spills or stains during decommissioning activities. Both programs outline documentation and remedial actions following discovery.

#### 8.6.7 Waste Water Discharges

Maine Yankee waste discharges were regulated by MDEP. MDEP assumed responsibility for administering the National Pollutant Discharge Elimination System (NPDES) program. MDEP also administers the State Waste Discharge License Program which mirrors the federal program. On April 13, 2001, MDEP issued waste discharge license renewal #ME0002569 and #W000746-SR-D-R. Discharges that occurred during decommissioning included drain down and flushing of various

tanks, systems and components, discharges included disposal of sump water, draining of the reactor cavity and ultimately, draining of the spent fuel pool. These activities were conducted in accordance the requirements of the associated, approved discharge permits issued by MDEP.

#### 8.6.8 Storm Water Management

Storm water management at Maine Yankee was historically addressed as part of the facility's NPDES permit. The NPDES permit required Maine Yankee to have a Storm Water Pollution Prevention Plan (SWPPP). The SWPPP was incorporated into Maine Yankee's Integrated Spill Plan. As part of the transition from an operating plant to a decommissioning plant, Maine Yankee filed a Notice of Intent for coverage under EPA's NPDES Storm Water Construction Permit (Permit MER10A416). As such, Maine Yankee prepared a SWPPP for the decommissioning construction activities. The SWPPP utilized Best Management Practices as outlined in the "Storm Water Management For Maine: Best Management Practices" (1995) and "Maine Erosion and Sediment Control Handbook for Construction: Best Management Practices" (1991). MDEP regulates storm water as part of their review of projects under various laws and regulations including Site Law, solid waste regulations and hazardous waste regulations.

#### 8.6.9 Air and Noise Emissions

Maine Yankee has a diesel generator that provides backup power for security. Operation of the diesel generator will comply with the applicable regulations. Fugitive emissions are addressed in the license which requires a fugitive emissions plan which Maine Yankee maintains and follows. Air emissions are also addressed as part of MDEP review of projects under various laws and regulations including Site Law, solid waste regulations and hazardous waste regulations.

Noise emissions from decommissioning activities are regulated under MDEP regulation Chapter 375, Section 10 and addressed and controlled per appropriate Maine Yankee Site Law permits. Compliance is accomplished by measures such as prior assessment of noise impact of planned decommissioning activities, implementation of appropriate engineered controls to minimize noise impact, and restrictions on working hours.

#### 8.6.10 Floral and Faunal Impacts

As part of their review of projects under Site Law, solid waste and hazardous waste and NRPA, MDEP consults with other agencies including IF&W, critical areas program and others as needed. Through this process, no unusual natural areas or

critical habitat or rare or endangered plant species have been identified on the Maine Yankee site. Other than occasional transient bald eagles and peregrine falcons, there are no known rare and endangered species present at the site (Reference 8.9.38). The federally-listed shortnose sturgeon is known to occur in the Back River and Montsweag Bay adjacent to the site. There will be no additional areas disturbed during decommissioning beyond those affected by plant construction or operation.

#### 8.6.11 Confirmatory Surveys

In addition to the confirmatory surveys which may be conducted by the NRC, state law requires Maine Yankee to permit monitoring by the Maine State Nuclear Safety Inspectors (22 MRSA 664, sub-§2, as amended by PL 1999, c. 739, §1 and 38 MRSA 1451, sub-§11, as amended by PL 1999, c. 741, §1) This monitoring includes, among other things, taking radiological measurements for the purpose of verifying compliance with applicable state laws and confirming and verifying compliance with NRC standards for unrestricted license termination.

#### 8.6.12 Cumulative Risk

State of Maine Law (L.D. 2496 Sec.3.38 MRSA 1455) indicates that the MDEP shall evaluate the cumulative risk posed by radiological and chemical contaminants that will remain at the site at which the decommissioning of a nuclear power plant is occurring or has been completed. An MDEP letter (dated February 22, 2001) proposed that Maine Yankee prepare the cumulative risk assessment. In response, by letter dated February 26, 2001, Maine Yankee confirmed its agreement to prepare the subject assessment with the understanding that MDEP will review and evaluate the assessment in accordance with the above cited law. The final report was approved by MDEP in March 2007.

#### 8.6.13 Possibility of Institutional Controls for Non-Radiological Impacts

As discussed in Section 1.4.1, this License Termination Plan describes an acceptable approach for demonstrating compliance with the radiological criteria for unrestricted use (as defined in 10 CFR 20.1402). The Radiologically Restricted Area (RRA) was radiologically released for unrestricted use. To assure compliance with non-radioactive environmental monitoring issues, the land was deeded with restrictive covenants against specific activities, consistent with the RCRA closure process, involving, such as excavating basements or drilling wells for drinking or irrigation water. Institutional Controls will be implemented as necessary governing intended site use and will be eliminated when no longer required. (See also Section 8.2.)

## 8.7 Evaluation of Decommissioning Low-Level Radioactive Waste (LLRW) Volume

The most significant change to Maine Yankee's plans for decommissioning since the submittal of the original PSDAR is the increase in volume of low level radioactive waste estimated to be generated. The original PSDAR estimated that the LLRW volume would be 209,000 cubic feet (5,920 cubic meters). The estimate of LLRW volume to be transported from Maine Yankee is 1,127,320 cubic feet (31,924 cubic meters) from the Maine Yankee Nuclear Power Plant. The LLRW volume estimated for final burial in a radioactive waste facility is less because of volume reduction. The increase in volume over that originally estimated in the PSDAR is a result Maine Yankee's decision, made in concert with Federal, State and Local stakeholders, to demolish all buildings to an elevation equivalent to three feet below grade and dispose of the demolition debris from the radiologically controlled (restricted) area at a low level radioactive waste disposal facility or other appropriate disposal facility. In addition, the decommissioning cost estimate for the ISFSI assumes that all of the material that comprises the ISFSI storage pads and Vertical Concrete Casks will be disposed of as low-level radioactive waste. Another change which has influenced this volume is the enhanced state cleanup standards that establish more restrictive exposure levels than the NRC regulation codified in 10 CFR Part 20, Subpart E.

### 8.7.1 Estimate of Maine Yankee LLRW Volume

LTP Section 3, Table 3-9 identifies the transportation mode and volume as well as the disposal method and volume for the items to be disposed of as LLRW.

The transportation modes identified by Table 3-9 include barge, rail and truck. Large components such as the reactor vessel, pressurizer and the three steam generators were shipped by barge. The total barge transportation volume for these components was 31,700 cubic feet. The non-GTCC packaged hardware and cutting grit associated with the reactor pressure vessel internals, dry active waste (DAW), resin containing transportation packages and the reactor pressure vessel head were transported by truck. The total truck transportation volume is 170,000 cubic feet. Rail transportation will transport the majority of the volume of LLRW for Maine Yankee's decommissioning. The items transported by rail include reactor coolant pump motors, contaminated soil and contaminated concrete. The total rail transportation volume is 925,000 cubic feet. The total LLRW transportation volume for all modes of transportation is 1,127,320 cubic feet (31,924 cubic meters). In addition, the material that comprises the ISFSI storage pads and the Vertical Concrete Casks is expected to be transported by rail.

The LLRW disposal modes identified in Table 3-9 include direct disposal and disposal after volume reduction processing. Items processed for volume reduction include the three steam generators, the pressurizer, other contaminated metal and dry active waste. This volume reduction process reduces the total volume of low level waste from these items from 185,470 cubic feet to 8,700 cubic feet. This represents a volume reduction ratio of about twenty-one to one. The remaining LLRW items are designated for direct disposal. Therefore, their transportation volume is the same as their disposal volume. The majority of the LLRW volume (941,850 cubic feet) designated for direct disposal consists of contaminated concrete (900,000 cubic feet), contaminated soil (25,000 cubic feet) and the reactor pressure vessel (9,500 cubic feet). The total LLRW disposal volume designated for disposal either directly or after processing is 950,550 cubic feet (26,920 cubic meters).

#### 8.7.2 FGEIS LLRW Volume Basis

The FGEIS on Decommissioning Nuclear Facilities, NUREG-0586, dated November 1988, evaluated the decommissioning of a generic "reference" Pressurized Water Reactor. The FGEIS concluded that decommissioning has many positive environmental impacts such as the return of possibly valuable land to the public domain and the elimination of potential problems associated with radioactively contaminated facilities with minimal use of resources. Adverse impacts identified by the FGEIS include routine occupational radiation doses and the commitment of nominally small amounts of land to radioactive waste disposal. Other impacts, including public radiation doses, are minor.

The FGEIS evaluates the generation of LLRW from decommissioning in the context of its impact on the commitment of radioactive waste disposal space and the dose to the public. The commitment of radioactive waste disposal space is related to the volume of LLRW for disposal. The dose to the public is related to the volume of LLRW being transported. The estimated LLRW volume used in the FGEIS for the reference PWR was the same for disposal and transportation. This volume totaled: 18,340 cubic meters (647,600 cubic feet). This volume was estimated based upon a radiological criteria of 25 mrem/yr and an assumption that buildings would be remediated and left standing.

The dose to the public from LLRW transportation was calculated by determining the number of truck shipments that would be required to transport 647,600 cubic feet of low-level waste. The number of shipments was calculated to be about 1,363. The dose to the public was based upon an external package dose rate of 10 mrem/hr at 2 meters away from the package.

The dose to the public totaled about 0.015 man-rem per shipment. This resulted in a total dose to the public from transportation of the entire decommissioning LLRW volume of 20.6 man rem.

The commitment of LLRW disposal space for a volume of 647,600 cubic feet was estimated to be less than 2 acres, assuming shallow-land burial of radioactive wastes in standard trenches. The FGEIS concluded that two acres of radioactive waste disposal space is small in comparison to the acreage freed up by decommissioning the reference plant (1,160 acres). The FGEIS also concluded that while decommissioning will generate an appreciable fraction of the LLRW generated by a PWR over its lifetime, the quantity of waste from all operating reactors will considerably exceed that generated from those facilities being decommissioned. Hence, any problems in waste disposal capacity will be the result primarily of operating nuclear plants rather than those being decommissioned. Therefore, the FGEIS recommends that before choosing a decommissioning option, e.g., DECON or SAFESTOR, the licensee should assess current waste disposal conditions and their impact on decommissioning.

#### 8.7.3 Impact of Maine Yankee's LLRW Volume

As described above in Section 8.7.1, Maine Yankee's decommissioning LLRW volume for transportation has been estimated at 1,127,320 cubic feet (31,924 cubic meters) and for disposal at 950,550 cubic feet (26,920 cubic meters). These volumes are greater than the volume estimated for the FGEIS reference plant at 647,600 cubic feet (18,340 cubic meters) by 74 % for transportation and 47 % for disposal.

The decommissioning cost estimate assumes that all of the material associated with the Vertical Concrete Casks and the ISFSI storage pads will be shipped offsite as low-level radioactive waste. This assumption was made to maximize the cost of disposal of radioactive materials in the decommissioning cost estimate. Maine Yankee does not anticipate that this material would be required to be disposed of to satisfy the NRC's 25 mRem/year release criteria.

In order to understand the impact of the increase in LLRW volume, Maine Yankee evaluated the expected dose to public from the transportation and the commitment of radioactive waste disposal space. The increased commitment of LLRW disposal space for the increased LLRW from the Maine Yankee decommissioning was determined by simply multiplying the NUREG 0586 value of 2 acres by 47% resulting in 0.94 acres. Thus, it is estimated that the commitment of LLRW waste facility space is 2.9 acres. This space is small in comparison to the acreage freed up by decommissioning Maine Yankee, 840

acres. Therefore, Maine Yankee's decommissioning LLRW volume is consistent with the conclusions of the FGEIS.

In addition, Maine Yankee considered the availability of LLRW disposal space in choosing its decommissioning option (DECON), as described above in Section 8.3.1, consistent with the recommendation of the FGEIS. Furthermore, the potential impact on LLRW disposal space has been diminished by MY's efficient planning and utilization of volume reduction techniques wherever possible. Disposal space availability for Maine Yankee has increased significantly with the establishment of contracts with the Waste Disposal Facility in Clive, Utah, and the volume reduction being realized through use of the many services offered by GTS Duratek Facilities in Tennessee.

The expected dose to the public from transportation of Maine Yankee's decommissioning LLRW was determined by examining the different modes of transportation planned for different sources of waste. It was estimated that the volume of concrete would fill 2,167 containers (20 cubic yard roll-offs) assuming a 30% volume swell upon demolition, rubblization and packaging. This quantity results in about 181 rail shipments assuming two intermodal rail cars per shipment loaded with 6 roll-off containers each. The remaining LLRW volume is conservatively estimated to require 364 truck shipments. This is conservative because some of this volume is transported by barge and by rail, as indicated above in Section 3.5, which imparts less dose to the public.

The dose to the public for each of these transportation modes is divided, consistent with the FGEIS, into two categories: on-lookers and the general public. On-lookers are assumed to constitute 10 persons who are exposed for 3 minutes each at close proximity per shipment. The FGEIS assumes this close proximity is two meters at an exposure rate of 10 mrem/hr. The dose to the general public is a function of the number of shipments and the traveling distance for each shipment. The FGEIS assumes 1363 shipments at a distance of 500 miles.

In order to calculate dose to the onlookers, for intermodal rail, Maine Yankee assumes the same close proximity of two meters at an exposure rate of 10 mrem/hr. For 10 persons (onlookers) exposed for 3 minutes at this exposure rate the dose is calculated to be 5 mrem per shipment. Therefore, the dose estimated to onlookers, for 181 rail shipments of Maine Yankee decommissioning LLRW waste is 0.91 man-rem. The dose to the general public from rail shipments of Maine Yankee decommissioning LLRW waste was calculated using WASH-1238, "Environmental Safety of Transportation of Radioactive Materials to and from Nuclear Power Plants" dated 1972

(Reference 8.9.23). Assuming the dose rates for Maine Yankee rail packages, which are about one third of the FGEIS assumed dose rates, the resulting dose to the general public was estimated to be about  $6.0 \text{ E-6}$  man-rem per mile. Even though the actual distance for rail shipments is about 2400 miles, the distance was conservatively assumed to be about 3000 miles. This results in a dose to the general public of  $1.8 \text{ E-2}$  man-rem per shipment. For 181 shipments, the dose to the general public totals 0.098 man-rem. Therefore, the total dose to the public from rail shipments of Maine Yankee LLRW is estimated to be 3.26 man-rem.

For the 364 truck shipments, Maine Yankee calculated the total number of shipments multiplied by the distance to be traveled by the trucks, 1200 miles. The total miles for all truck shipments of Maine Yankee decommissioning LLRW is 436,800 miles versus the FGEIS total of 681,500 miles. In order to calculate the dose to the public from both onlookers and the general public, the FGEIS dose of 20.6 man-rem was multiplied by the ratio of total truck shipment distance for Maine Yankee to that in the FGEIS. The resulting dose to the public for the truck shipments of Maine Yankee decommissioning LLRW is about 13.4 man-rem.

In Supplement 1 to NUREG 0586, the very low activity waste does rates were considered to be so low that they did not have to be considered in the transportation dose estimate. All of the material associated with the Vertical Concrete Casks and the ISFSI storage pads that will be shipped to a low-level radioactive waste site is considered to be very low activity waste.

Therefore the total dose to the public from the transportation of LLRW associated with the decommissioning of Maine Yankee is about 17.6 man rem. This dose impact is less than the impact estimated for the reference plant in the FGEIS (21 man-rem) and is primarily attributed to the choice of rail shipment to a radioactive waste storage facility rather than truck shipments. Thus, the environmental impacts of the volume of low level waste to be generated from the decommissioning of Maine Yankee are bounded by the impacts of the reference plant evaluated in the FGEIS.

In addition, extending the storage period through 2034 does not have a significant impact, because all applicable federal and state regulations will be met during this time period.



## 8.8 Summary

This supplement to the MYER describes any new information or significant environmental change associated with decommissioning and license termination. The original environmental report for Maine Yankee demonstrated that the construction and operation of the Maine Yankee plant would result in no unacceptable effects on the environment. The change in environmental impact due to decommissioning Maine Yankee is generally favorable; no significant environmental changes have been identified. In most cases decommissioning eliminates or further reduces the already small environmental effects that have been associated with operation of the facility. There are certain environmental effects which will be increased due to decommissioning activities. These include the occupational radiation exposure necessary for decommissioning activities, the radiation exposure to the public associated with transportation of low-level radioactive waste, and the commitment of small amounts of land at the burial site for disposal of this low-level radioactive waste. However, these estimated effects for Maine Yankee's decommissioning/license termination activities are within the basis and intents of the effects previously evaluated by the NRC on a generic basis. Also, the consequences of postulated accidents and events which could occur during decommissioning would have no significant adverse environmental effects. Therefore, the proposed decommissioning of the Maine Yankee facility will have no unacceptable impacts on the environment.

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**MAINE YANKEE**

**LTP SECTION 9**

**ACRONYMS**

## ACRONYMS

AEC	Atomic Energy Commission
AF	Area Factor
ALARA	As Low As Reasonably Achievable
ANI	American Nuclear Insurers
ANSI	American National Standards Institute
AS	Auxiliary Steam
ASLB	Atomic Safety and Licensing Board [NRC}
AUX	Auxiliary
AWJ	Abrasive Water Jet
BAMT	Boric Acid Mix Tank
BAST	Boric Acid Storage Tank
BWST	Borated Waste Storage Tank
C of C	Certificate of Compliance
CAP	Community Advisory Panel
CCR	Cured Concrete Rubble
CCS	Continued Characterization Survey
CDD	Construction Demolition Debris
CDE	Committed Dose Equivalent
CEDE	Committed Effective Dose Equivalent
CERCLA	Comprehensive Environmental Response, Compensation and Liabilities Act
CFH	Certified Fuel Handler
CFR	Code of Federal Regulations
Ci	Curie
CMP	Central Maine Power
CS	Containment Spray
CST	Condensate Storage Tank
CTMT	Containment
CVCS	Chemical Volume and Control System
CW	Circulating Water
CWPH	Circulating Water Pump House
D&D	Dismantlement and Decontamination
DAW	Dry Active Waste
DCGL	Derived Concentration Guideline Level

## ACRONYMS

DFPP	Decommissioning Fire Protection Program
DHE	Division of Health Engineering [Maine]
DHS	Department of Human Services [Maine]
DMR	Department of Marine Resources (State of Maine)
DOC	Decommissioning Operations Contractor
DOE	Department of Energy
DOT	Department of Transportation
dpm	Disintegrations Per Minute
DQO	Data Quality Objective
DRO	Diesel Range Organics
DSAR	Defueled Safety Analysis Report
DWO	Decommissioning Work Order
DWST	Demineralized Water Storage Tank
ECCS	Emergency Core Cooling Systems
EMC	Elevated Measurement Comparison
EPA	Environmental Protection Agency
EVS	Earned Value Schedule
FERC	Federal Energy Regulatory Commission
FGEIS	Final Generic Environmental Impact Statement
FHE	Fuel Handling Equipment
FOC	Friends of the Coast
FP	Fuel Pool
FSAR	Final Safety Analysis Report
FSS	Final Status Survey
GEIS	Generic Environmental Impact Statement
GeLi	Germanium - Lithium
GPS	Global Positioning System
GTCC	Greater Than Class C
HAZMAT	Hazardous Materials
HEPA	High Energy Particulate Air
HLW	High Level Waste
HSA	Historical Site Assessment
HTD	Hard To Detect
HVAC	Heating, Ventilation, and Air Conditioning



## ACRONYMS

ICI	In Core Instrumentation
IF&W	Inland Fisheries and Wildlife (State of Maine)
INPO	Institute of Nuclear Power Operations
ISFSI	Independent Spent Fuel Storage Installation
ITDC	Important To the Defueled Condition
KV	Kilovolt
KW	Kilowatt
LBGR	Lower Bound Grey Region
LLD	Lower Limit of Detection
LLRW	Low Level Radioactive Waste
LLWF	Low Level Waste Facility
LLSW	Low Level Waste Storage
LLWSB	Low Level Waste Storage Building
LPG	Liquid Petroleum Gas
LSA	Low Specific Activity
LTP	License Termination Plan
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual (NUREG-1575, EPA 402-R-97-016) 12/97
MCC	Motor Control Center
MDA	Minimum Detectable Activity
MDC	Minimum Detectable Concentration
MDCR	Minimum Detectable Count Rate
MDEP	Maine Department of Environmental Protection
MDER	Minimum Detectable Exposure Rate
MDOT	Maine Department of Transportation
MEPDES	Maine Pollutant Discharge Elimination System
MET	Meteorological
MDHS	Maine Department of Health Services
MHPC	Maine Historic Preservation Commission
MSL	Mean Sea Level
MY	Maine Yankee
MYAPC	Maine Yankee Atomic Power Company
MYER	Maine Yankee Environmental Report
MYQAP	Maine Yankee Quality Assurance Program

## ACRONYMS

NAC	Nuclear Assurance Corporation
NAI	Sodium - Iodide
NIST	National Institute of Standards Technology
NMFS	National Marine Fisheries Service
NMSS	Nuclear Materials Security and Safeguards
NORM	Naturally Occurring Radioactive Material
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NRPA	Natural Resources Protection Act
NSSS	Nuclear Steam Supply System
ODCM	Offsite Dose Calculation Manual
OSHA	Occupational Safety and Health Administration
PAB	Primary Auxiliary Building
PAG	Protective Action Guidane
PCB	Poly Chlorinated Biphenyls
PCC	Primary Component Cooling
PCP	Process Control Program
PMP	Project Management Procedure
PE	Personal Protective Equipment
ppm	Parts Per Million
PSDAR	Post-Shutdown Decommissioning Activities Report
PW	Potable Water
PWST	Primary Water Storage Tank
PZR	Pressurizer
QAP	Quality Assurance Program
QAPP	Quality Assurance Project Plan
QAR	Quality Assurance Related
QC	Quality Control
RA	Restricted Area
RAI	Request for Additional Information
RCA	Radiological Controlled Area - (Pre 10CFR20 Revision 1994)
RCP	Reactor Coolant Pump
RCRA	Resource Conservation Recovery Act
RCS	Reactor Coolant System

## ACRONYMS

REM	Radiation Equivalent Man
REMP	Radiological Environmental Monitoring Program
RESRAD	RESidual RADioactivity (Computer Code)
RETS	Radiological Effluent Technical Specifications
RFI	RCRA Facility Investigation
RMS	Radiation Monitoring System
RP	Radiation Protection
RPD	Relative Percent Difference
RPM	Radiation Protection Manager
RPV	Reactor Pressure Vessel
RWST	Refueling Water Storage Tank
RX	Reactor
S&W	Stone & Webster
SAP	Sampling and Analysis Plan
SAR	Safety Analysis Report
SCAT	Spray Chemical Addition Tank
SCC	Secondary Component Cooling
SCDHEC	South Carolina Department of Health and Environmental Control
SD	Storm Drain
SDP	Site Development Plan
SEC	Security
SERT	System Evaluation Reclassification Team
SFDT	Spent Fuel Disposal Trust
SFP	Spent Fuel Pool
SFPI	Spent Fuel Pool Island
SG	Steam Generator
SHR	Site History Report
SOB	Security Operations Building
SRP	Savannah River Project
SSC	Systems, Structures & Components
SU	Survey Unit
SVOC	Semivolatile Organic Compounds
SVOCs	Semivolatile organic compounds
SW	Service Water

## ACRONYMS

SWEC	Stone & Webster Engineering Corporation
SYS	System
SWPPP	Storm Water Pollution Prevention Plan
TAP	Technical Advisory Panel
TB/SB	Turbine Building/Service Building
TE	Technical Evaluation
TEDE	Total Effective Dose Equivalence
TK	Tank
TLD	Thermo Luminescent Dosimeter
TRU	Transuranic
TSCA	Toxic Substances Control Act
TURB	Turbine
UMS	Universal Multipurpose System (Cask)
USCG	United States Coast Guard
USDOE	United States Department of Energy
USDOT	United States Department of Transportation
USF&WS	United States Fish and Wildlife Service
VCT	Volume Control Tank
VOC	Volatile Organic Compounds
WMG	Waste Management Group
WMP	Waste Management Plan
WPB	Wiscasset Planning Board
WRS	Wilcoxon Rank Sum (test)
XFMR	Transformer