1 INTRODUCTION

1.1 Overview of NRC Site Decommissioning

At sites and facilities licensed by the Nuclear Regulatory Commission (NRC), the formal decommissioning process begins when a licensee decides to terminate licensed activities. The majority of licenses terminated each year by NRC involve little or no site remediation and, therefore, present no complex decommissioning problems owing to residual radioactivity. However, license termination at a small number of sites is far more complex because contamination may be spread into various areas within the facility and surrounding areas by the movement of materials and equipment, by activation, and by the dispersion of air, water, or other fluids through or along piping, equipment, walls, floors, and drains. Decontamination of such areas is likely to be performed at nuclear power plants, non-power (research and test) reactors, fuel fabrication plants, uranium hexafluoride production plants, and independent spent fuel storage installations. A small number of universities, medical institutions, radioactive source manufacturers, and companies that use radioisotopes for industrial purposes may also contain radioactive contamination that requires remediation.

NRC regulations in 10 CFR 30.36, 40.42, 50.82, 70.38, and 72.54 require licensees to remove their facilities from service safely. As part of the decommissioning process, licensees are required to demonstrate that residual radioactivity in facilities and environmental media has been reduced to acceptable levels. Typically, licensees demonstrate compliance with radiological criteria for license termination by conducting final status surveys of the site or facility and reporting the survey results to NRC for evaluation. Where appropriate, the NRC staff conducts confirmatory surveys to verify that lands and structures have been adequately remediated.

On July 21, 1997, the NRC amended the regulations in 10 CFR Part 20 to include explicit radiological criteria for decommissioning (62 FR 139, pp. 39057– 39092). Subpart E of the amended regulations contains dose-based radiological criteria for restricted and unrestricted release, consisting of a total effective dose equivalent (TEDE) limit for residual radioactivity above background. These regulations replace prior NRC guidance based on surface and volume activity concentration limits for specific radionuclides.

To implement the dose criteria in the amended 10 CFR Part 20, final status surveys and confirmatory surveys must be capable of detecting very low levels of residual radioactivity in the presence of background at a variety of NRC-licensed facilities and sites. An essential component of such surveys is a statistical methodology that is appropriate for radiological data at or near background levels. This document presents such a methodology.

1.2 Need for This Report

Previously, the NRC staff used guidance for conducting final status radiological surveys that is contained in draft report NUREG/CR-5849 (1992), entitled “Manual for Conducting Radiological Surveys in Support of License Termination.” This report contains an alternative statistical approach for designing radiological surveys. The framework for the survey design is

the Data Quality Objectives (DQO) process. The DQO process uses statistical hypothesis testing rather than the construction of confidence intervals. This allows a balance to be reached between the risk of possibly releasing an incompletely remediated site and the risk of possibly requiring further remediation at an already adequately remediated site. One of the primary goals of the DQO process is the determination of acceptable decision error rates for the hypothesis test, i.e., those that will reflect the relative importance of these risks at a specific site. The DQO process is used to incorporate site-specific information and sound scientific judgment into the survey design and data analysis so that the objective of safely releasing a site can be met while reducing the number of unnecessarily arbitrary and conservative assumptions that are sometimes invoked in the face of uncertainty.

Using the DQO framework, the amount and type of data to be collected are related to the specific decision to be made rather than sampling at a fixed density. The number of samples of measurements needed in a survey unit is determined by the acceptable decision error rates, the magnitude of the release criterion relative to the overall variability of the data, and the sensitivity of the scanning method used. The type and amount of scanning required depend primarily on the classification of the survey unit. Three classes of survey units are used to direct the survey effort at a level commensurate with the potential for residual radioactivity in excess of the release criterion. Acceptable areas of elevated activity are determined by radionuclide-specific area factors derived from an appropriate dose model.

The nonparametric statistical techniques described in this report do not require the data to be normally or log-normally distributed and are, therefore, expected to be more appropriate for determining the number of samples required for radiological surveys and analyzing data collected at or near background levels. These tests perform almost as well as the parametric tests even when the data are normally distributed, are less sensitive to outliers, and are better able to handle data sets that include *non-detects*.

There are two possible approaches to demonstrating compliance with criteria that specify a dose limit due to residual radioactivity distinguishable from background, depending on which of the following questions is emphasized:

(1) Does the dose due to residual radioactivity exceed the limit?
(2) Is the residual radioactivity indistinguishable from background?

In the initial draft of NUREG-1505 (August 1995) the approach emphasized question 2. This final report addresses both approaches.

1.3 Objective of This Report

This report describes a nonparametric statistical methodology that NRC licensees may consider when evaluating methods for demonstrating compliance with the radiological criteria for license termination in Subpart E of 10 CFR Part 20. The DQO process (EPA QA/G-4 and QA/G-9, 1994) is used as the framework for the planning of final site surveys. The statistical approach described in this report is expected to be a resource-efficient solution for the design of final status decommissioning surveys when radiological criteria for decommissioning approach background

levels. The proposed process includes methods for determining the number of samples needed to obtain statistically valid comparisons with decommissioning criteria and the methods for conducting the statistical tests with the resulting sample data.

No single statistical formulation can adequately anticipate every contingency that will arise in deciding whether a survey unit can be safely released. The DQO process should be used to determine whether a proposed action will further the objective of safely releasing the site. The decisions reached may not always be accompanied by a numerical procedure leading to that decision. However, such decisions should always be accompanied by a description of which actions were taken, and why. The DQO process provides a methodology for resolving the often complex issues surrounding site remediation and decommissioning.

1.4 Structure of This Report

This report is divided into four major parts. The first part deals with general final status survey design criteria, definitions, and data quality objectives (Chapters 2 and 3). The second part describes preliminary data analysis and data quality assessment (Chapter 4). The third part describes the use of the statistical tests recommended in this report (Chapters 5 through 8). These first eight chapters contain all of the information required to design and conduct final status surveys, and to analyze and interpret the results. Chapters 9 through 14 deal with extensions of, and alternatives to, the statistical procedures that may be applicable in some situations. Chapters 15 and 16 contain a Glossary and Bibliography, respectively. The appendix contains the statistical tables needed to perform the analyses described in this report.