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September 25, 2002

Susan M. Cange, Lead Reindustrialization Specialist
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Dear Ms. Cange:

Revision to "Design of Radiological Survey and Sampling to Support Title Transfer or Lease of Property on the Department of Energy Oak Ridge Reservation"

Enclosed you will find ten copies of the revised draft report entitled, *Design of Radiological Survey and Sampling to Support Title Transfer or Lease of Property on the Department of Energy Oak Ridge Reservation* (BJC/OR-554-R1). The document, initially issued in 2000 to support Reindustrialization's leasing activities has been revised to incorporate title transfers as well, and is provided for your transmittal to the Tennessee Department of Environment and Conservation, the Tennessee Division of Radiological Health, and the Environmental Protection Agency, Region 4.

As a part of its revision, the document received several reviews. Reviewing organizations include the Department of Energy Reindustrialization program, Bechtel Jacobs Company's (BJC) Reindustrialization, and Radiological Control (RadCon) organizations, as well as Science and Ecology Corporation, Inc., who provide technical and field implementation support to RadCon. All comments received have been incorporated with the objectives of maintaining the technical accuracy of the document and enhancing its readability.

Once agreed to by all parties the document will be incorporated into the transfer protocols presently under development and as a foundational component in the development of all of our future survey plans.

Please send copies of correspondence pertaining to these documents to me at the Federal Office Building, Room 1011. If you have any questions in regard to this material or require additional information, please do not hesitate to contact me at (865) 241-9440.

Sincerely,

Lesley T. Cusick

Lesley T. Cusick
Regulatory Affairs Manager
Reindustrialization Program

LTC: ltc:rs

Enclosure (10): *Design of Radiological Survey and Sampling to Support Title Transfer or Lease of Property on the Department of Energy Oak Ridge Reservation* (BJC/OR-554-R1)

Susan Cange
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September 25, 2002

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**Design of Radiological Survey and
Sampling to Support Title Transfer
or Lease of Property on the
Department of Energy
Oak Ridge Reservation**

This document is approved for public release per
review by:

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MANAGED BY
BECHTEL JACOBS COMPANY LLC
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

contributed to the preparation of this document and should not
be considered an eligible contractor for its review.

**Design of Radiological Survey and
Sampling to Support Title Transfer
or Lease of Property on the
Department of Energy
Oak Ridge Reservation**

Date Issued—September 2002

Prepared by
Science Applications International Corporation
Oak Ridge, Tennessee
under subcontract 23900-BA-PR007U WR000300

Prepared for the
U.S. Department of Energy
Office of Assets Utilization

BECHTEL JACOBS COMPANY LLC
managing the
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East Tennessee Technology Park
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ACRONYMS

ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
BEAR	Baseline Environmental Analysis Report
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CROET	Community Reuse Organization of East Tennessee
DCGL	Derived Concentration Guideline Level
DOE	U.S. Department of Energy
DOE-ORO	DOE-Oak Ridge Operation
EBS	Environmental Baseline Summary
EMC	elevated measurement comparison
EPA	U.S. Environmental Protection Agency
ETTP	East Tennessee Technology Park
LBGR	Lower Boundary of the Gray Region
MARRISM	<i>Multi-Agency Radiation Survey and Site Investigation Manual</i>
MDA	minimum detectable activity
MDC	minimum detectable concentration
mrem	millirem
NaI	sodium iodide
NIST	National Institute of Standards and Technology
ORR	Oak Ridge Reservation
RC	risk calculation
RCRA	Resource Conservation and Recovery Act
RCT	Radiological Control Technician
RSSI	Radiation Survey and Site Investigation
SAP	Sampling and Analysis Plan
SHHRA	Screening-Level Human Health Risk Assessment
TDEC	Tennessee Department of Environment and Conservation
TEDE	total effective dose equivalent
TRU	transuranic

EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) owns, operates, and manages the buildings and land areas on the Oak Ridge Reservation (ORR) in Oak Ridge, Tennessee. As land and buildings are declared as excess or underutilized, consistent with management, planning, and clean-up consideration, it is the intent of DOE to either transfer the title of or lease suitable property to the Community Reuse Organization of East Tennessee (CROET) or other entities for public use. The DOE Reindustrialization Program is responsible for this effort. It is DOE's responsibility, in coordination with the U.S. Environmental Protection Agency (EPA), Region 4, and the Tennessee Department of Environment and Conservation (TDEC), to ensure that the land, facilities, and personal property that undergo title transfer or lease are suitable for public use. Release of personal property must also meet site requirements and be approved by the DOE contractor responsible for site radiological control.

In 1996, the DOE Oak Ridge Operation (DOE-ORO) established the Reindustrialization Program as an innovative way to address some of the environmental and financial challenges left by the end of the cold war. Under the Reindustrialization Program, DOE converts use of real property (excess or underutilized land and facilities) by lease or title transfer with the goals of accelerating clean up by reducing associated costs while allowing for productive use of these assets by the private sector. This process offsets negative impacts on the community from unemployment as a result of DOE downsizing, work force restructuring, and related economic spillover effects.

DOE-ORO, EPA, and the State of Tennessee signed the Oak Ridge Performance Management Plan in June 2002, and DOE-ORO is now transitioning to an accelerated approach to cleanup and risk reduction. While risk reduction is the primary driver, accelerated cleanup will also reduce mortgage costs, which will free money for reinvestment in near-term risk reduction projects. As part of this accelerated process, there will be increasing emphasis on title transfers of facilities and land.

The purpose of this document is to describe the radiological survey and sampling protocols that are being used to assess the radiological conditions of building and land areas on the Oak Ridge Reservation that contain space potentially available for title transfer or lease. The predecessor of this document was primarily focused on leasing. With the shift from leasing to title transfer, the emphasis is on protocols for title transfer (although the leasing protocols are also included). Most of the requirements are the same for title transfer and leasing; the differences will be explained and highlighted in summary tables.

This document is the basis for preparing radiological survey plans and sampling and analysis plans. After necessary surveys, sampling, and laboratory analyses are completed, the data are analyzed and included in an Environmental Baseline Summary (EBS) report for title transfer or in a Baseline Environmental Analysis Report (BEAR) for lease. The data from the BEAR is then used in a Screening-Level Human Health Risk Assessment (SHHRA) to assess the potential risks to future owners/occupants. If title is to be transferred, release criteria in the form of specific activity concentrations called Derived Concentration Guideline Levels (DCGLs) will be developed for the each property. The DCGLs are based on the risk model and are used with the data in the EBS to determine, with statistical confidence, that the release criteria for the property have been met.

The scope and extent of measurements required for each survey will be based on a graded approach, depending on the levels of contamination expected from historical operations and data according to the class definitions presented in NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*.

It is anticipated that limited sampling and laboratory analysis will be necessary to 1) confirm the established ratios for the radionuclides for indoor areas, 2) further define the areal extent of potential contamination, and 3) determine maximum contamination levels within an area. Sampling and analysis plans will be prepared for each site, as necessary, and will be reviewed by the regulators prior to implementation.

Specific survey protocols have been developed for each MARSSIM class definition based on established data quality objectives (DQOs). Survey and sampling is performed only to the extent that is necessary to supplement existing data to obtain the statistically significant number of data points required to meet the DQOs.

1. INTRODUCTION AND SCOPE

The U.S. Department of Energy (DOE) owns, operates, and manages the buildings and land areas on the Oak Ridge Reservation (ORR) in Oak Ridge, Tennessee. As land and buildings are declared excess or underutilized, it is the intent of DOE to either transfer the title of or lease suitable property to the Community Reuse Organization of East Tennessee (CROET) or other entities for public use. It is DOE's responsibility, in coordination with the U.S. Environmental Protection Agency (EPA), Region 4, and the Tennessee Department of Environment and Conservation (TDEC), to ensure that the land, facilities, and personal property that are to have the title transferred or are to be leased are suitable for public use. Release of personal property must also meet site requirements and be approved by the DOE contractor responsible for site radiological control.

The terms title transfer and lease in this document have unique meanings. Title transfer will result in release of ownership without any restriction or further control by DOE. Under lease conditions, the government retains ownership of the property along with the responsibility to oversee property utilization. This includes involvement in the lessee's health, safety, and radiological control plans and conduct of site inspections. It may also entail lease restrictions, such as limiting access to certain areas or prohibiting digging, drilling, or disturbing material under surface coatings. Survey and sampling requirements are generally more rigorous for title transfer than for lease. Because of the accelerated clean up process, there is an increasing emphasis on title transfers of facilities and land.

The purpose of this document is to describe the radiological survey and sampling protocols that are being used for assessing the radiological conditions and characteristics of building and land areas on the Oak Ridge Reservation that contain space potentially available for title transfer or lease. After necessary surveys and sampling and laboratory analyses are completed, the data are analyzed and included in an Environmental Baseline Summary (EBS) report for title transfer or in a Baseline Environmental Analysis Report (BEAR) for lease. The data from the BEAR is then used in a Screening-Level Human Health Risk Assessment (SHHRA) or a risk calculation (RC) to assess the potential risks to future owners/occupants. If title is to be transferred, release criteria in the form of specific activity concentrations called Derived Concentration Guideline Levels (DCGLs) will be developed for the each property. The DCGLs are based on the risk model and are used with the data in the EBS to determine, with statistical confidence, that the release criteria for the property have been met.

The goal of the survey and sampling efforts is to 1) document the baseline conditions of the property (real or personal) prior to title transfer or lease, 2) obtain enough information that an evaluation of radiological risks can be made, and 3) collect sufficient data so that areas that contain minimal residual levels of radioactivity can be identified and, following radiological control procedures, be released from radiological control. (It should be noted that release from radiological control does not necessarily mean free release because DOE may maintain institutional control of the site after it is released from radiological control).

To meet the goals of this document, a Data Quality Objective (DQO) process will be used to enhance data collection efficiency and assist with decision-making. The steps of the DQO process involve stating the problem, identifying the decision, identifying inputs to the decision, developing study boundaries, developing the decision rule, and optimizing the design. This document describes the DQOs chosen for surveys and sampling efforts performed for the purposes listed above.

The previous version to this document focused on the requirements for radiological survey and sampling protocols that are be used for leasing. Because the primary focus at this time is on title transfer, this revision applies to both situations. While most of the requirements are the same for title transfer and leasing, where

they differ in protocol, the differences will be explained and highlighted in summary tables as illustrated below in Table 1.

Table 1. Use of Summary Tables

Title Transfer	Lease
Tables like this one will be used to highlight similarities and/or differences between title transfer and leasing protocols.	

The protocols described in this document are based on an approach similar to that found in NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*, which provides detailed guidance for planning, implementing, and evaluating radiological surveys conducted to demonstrate compliance with a dose- or risk-based regulation. The primary focus of MARSSIM is the demonstration of compliance during the final status survey following scoping, characterization, and remedial actions, if necessary. MARSSIM also makes recommendations for preliminary surveys performed earlier in the process and recommends a series of surveys called the Radiation Survey and Site Investigation (RSSI) Process. This process includes six potential steps:

- 1) site identification,
- 2) historical site assessment,
- 3) scoping survey,
- 4) characterization survey,
- 5) remedial action support survey, and
- 6) final status survey.

The scoping survey may provide information for purposes other than compliance demonstration, such as to provide information to classify or rank facilities, evaluate remedial alternatives, protect health and safety of workers, or perform a preliminary hazard assessment. Surveys conducted for title transfer are final status surveys. Surveys conducted to support lease are scoping surveys and are performed primarily for baseline condition determination, risk assessment, and 10 *CFR* 835 compliance, which are purposes other than the final status survey. In the latter case, MARSSIM guidance will only be used to classify survey units and to calculate a representative number of surveys to be performed and/or samples to be collected for laboratory analyses. For property title transfer, further statistical test found in MARSSIM, that are intended to show status of compliance to a release criteria, will be performed. Table 2 highlights the similarities and/or differences between title transfer and leasing protocols for MARSSIM guidance use.

Table 2. MARSSIM Guidance Use Summary

Title Transfer	Lease
MARSSIM guidance and protocols, including statistical tests, will be employed to show status of compliance to release criteria.	MARSSIM guidance and statistical tests will only be used to classify survey units and to calculate a representative number of surveys to be performed and/or samples to be collected for laboratory analyses.

2. DATA QUALITY OBJECTIVES

Planning for MARSSIM-type surveys and sampling efforts is based on the DQO process defined by the EPA (EPA QA/G-4, 1994) to ensure that the type, quantity, and quality of environmental data used in decision making are appropriate for the intended application. The DQOs are qualitative and quantitative statements that clarify the study objective, define the most appropriate data to collect, determine the most appropriate conditions for collecting the data, and specify acceptable levels of decision errors that will be used as the basis for establishing the quantity and quality of data needed to support the decision. The DQO process is iterative, so that any and all of the specifications may change as new information is obtained during the course of site characterization and remediation. The DQO process is comprised of the following subheadings, and each will be discussed as it applies to the scope of this document.

2.1 STATEMENT OF THE PROBLEM

The goal of the survey and sampling efforts is to collect sufficient data to 1) document the baseline conditions of the property (real or personal) prior to title transfer or lease, 2) obtain enough information so that an evaluation of radiological risks can be made, and 3) collect data so that areas that contain minimal residual levels of radioactivity can be identified and, following radiological control procedures, may be released from radiological control. In addition, for title transfer, the goal is to statistically demonstrate that the property meets the release criteria. These objectives will be met by performing surveys and sampling in individual survey units. Typically, some information is currently available to describe the nature and extent of the contamination. The survey and sampling activities are intended to collect more detailed information, such as the location and extent of residual radioactivity and estimates of the concentration levels and its temporal and spatial variability.

2.2 IDENTIFICATION OF THE DECISION

In accordance with DOE Order 5400.5, the primary dose limit for any member of the general public is 100 millirem (mrem) total effective dose equivalent (TEDE) in a year. This limit applies to the sum of internal and external doses resulting from all modes of exposure to all radiation sources except background radiation and doses received as a patient from medical sources. Because the primary dose limit is for all sources, DOE Order 5400.5 specifies the dose from any one source must be a fraction of the primary dose limit and suggests a dose constraint of one quarter of the primary dose limit (i.e., 25 mrem/year) as an appropriate fraction to be applied to each DOE source or practice. This dose constraint ensures DOE real property releases are consistent with dose requirements in 10 *CFR* 20, "Standards for Protection Against Radiation," subpart E, "Radiological Criteria for License Termination." In addition, this limit is in agreement with a limit of 25 mrem/year from radioactive waste found in draft DOE regulation 10 *CFR* 834, Subpart E, Section 834.221. This criterion specifies that a site will be considered acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a TEDE to an average member of the critical group that does not exceed 25 mrem per year. Although this regulation is not final, the Reindustrialization Program has adopted this goal. DOE Order 5400.5 also requires that all radiological releases to the public be controlled to ensure they are maintained at levels that are as low as reasonably achievable (ALARA). Authorized limits for annual dose from the release of property should be as far below 25 mrem as is practicable. This dose constraint represents an upper bound or "cap" for ALARA-based authorized limits. Given this, the first decision statement is as follows: **"Is there statistical**

confidence that the TEDE for the modeled receptors is less than 25 mrem/year or other ALARA-based authorized dose limits?"

DOE allows the use of generic guidelines for concentrations of thorium and radium in soil and for surface contamination. Otherwise, authorized limits are to be established based on environmental pathway analysis and dose modeling using site-specific data. The results of the dose modeling are input into an ALARA evaluation to determine if the doses are ALARA or if it is reasonable to further reduce the levels of residual radioactivity to levels below those necessary to meet the dose criteria above. The ALARA evaluation documents the societal, environmental, technological, economic, and public policy factors, including an examination of the maximum dose to members of the public, collective dose to the population, doses to workers, applicable alternative processes for control, doses and cost for each alternative, and societal and environmental impacts of the alternatives.

The second objective is to determine the total risk of cancer incidence using enough samples to provide significance at a risk of 10^{-5} from all radiological sources associated with site processes. This risk criterion for significance is derived from the EPA Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) considerations. EPA uses the target risk range of 10^{-4} to 10^{-6} . The logarithmic midpoint of that range was agreed to by DOE, EPA, and TDEC as a target risk level for the sampling design. Title transfers will also be performed under EPA CERCLA regulations with concurrence from EPA and the state. Therefore, release of facilities to CROET or other organizations will also be based on control of the total risk of cancer incidence to the CERCLA risk range of 10^{-6} to 10^{-4} from all known chemical and radiological sources. Therefore, the second decision statement is as follows: **"Is there statistical confidence that the risks for the modeled receptors from all known chemical and radiological sources is less than 10^{-5} ?"** For risk assessments and risk calculations, the results will be screened at the 10^{-6} risk level (exposure scenario protocols defined further below) and risks will be calculated for all results above that level.

The third goal is to release from radiological control areas that contain minimal residual levels of radioactivity. According to 10 *CFR* 835, areas can be released from radiological control if the surface contamination values are less than those in the table presented in Appendix D to Part 835. 10 *CFR* 835 will be supplemented with the release criteria established in DOE Order 5400.5 for transuranic (TRU) radionuclides because the DOE Order 5400.5 limits are lower. For areas where a mixture of radionuclides exists that are in different groups with different limits, the limits will be applied independently for each group based on established or measured radionuclide ratios. For soil contamination areas, DOE 5400.5 either permits or requires use of concentration-based constraints as well for release of property. Soil clean-up levels established under the DOE Environmental Management Program for title environmental cleanup may be adopted for title transfer. Therefore, the third decision statement is as follows: **"Have the alpha or beta-gamma surface contamination limits and/or soil concentration limits been met in individual survey units?"**

It has been shown through modeling that the dose and risk that would be obtained from exposure to activity at the surface contamination limits listed in 10 *CFR* 835 and DOE 5400.5 would be less than the dose and risk criteria listed above for the expected radionuclide ratios. Furthermore, these authorized limits for surface contamination are also considered to be ALARA. Therefore, the surface contamination limits will be used as the DCGLs for surface contamination measurements. Release of personal property must also meet site requirements and be approved by the DOE contractor responsible for site radiological control. For volumetric or mass contamination measurements, such as for water or soil concentrations, DCGLs for property lease will be based on the generic guidelines for thorium and radium found in DOE Order 5400.5 and based on specific survey unit modeling to the 10^{-5} risk level, using an industrial worker scenario, for other radionuclides, assuming the unity rule (for the sum of the fractions) for all radioisotopes based on an established isotopic ratio. For title transfer, soil DCGLs may alternatively be based on soil clean-up levels established under the DOE Environmental Management Program. These concentration limits are also considered to be ALARA based on the negotiations conducted with the regulators. These DCGLs are

appropriate for unrestricted title transfer (free release) of property to the public and become the release criteria. When the property is being leased and not undergoing title transfer, the DCGLs are not established for clean-up or free-release decisions, but are used to aid in the classification of survey units and so that they can be used to calculate the appropriate number of samples to collect. Table 3 highlights the similarities and/or differences between title transfer and leasing protocols for DCGL use.

Table 3. DCGL Use Summary

Title Transfer	Lease
DCGLs are established for unrestricted title transfer (free release) of property to the public and become the release criteria.	DCGLs are only used to aid in the classification of survey units and to calculate the appropriate number of samples to collect.

The DCGLs listed above assume that the residual radioactivity is uniformly distributed across the survey unit and are designated $DCGL_W$. The sampling data taken at distinct locations in the survey unit will be averaged and reviewed to determine whether the survey unit meets the decision criterion. The surface contamination control criteria require averaging data across no more than 1 m^2 . However, since modeling has shown that these criteria meet the dose and risk objectives, they will be applied to the average across the entire survey unit, but for lease situations and soil concentrations only. Under these circumstances, a separate DCGL for elevated measurement comparison ($DCGL_{EMC}$) can be calculated by assuming that residual radioactivity is concentrated in a much smaller area, i.e., in only a small percentage of the entire survey unit. The $DCGL_{EMC}$ is normally calculated for survey planning purposes based on an area determined by the spacing between adjacent sampling locations. The $DCGL_{EMC}$ is for concentrations of radionuclides in areas equal to or less than 25 m^2 but greater than 1 m^2 and should average less than the $DCGL_W$ times the square root of the quotient of 100 m^2 and the area of the hot spot in square meters [i.e., $DCGL_{EMC} = DCGL_W \cdot (100/A_{hs})^{0.5}$]. There is currently only draft guidance that would allow the application of this elevated measurement approach to transfer (release) of surface contaminated property. Therefore, until that guidance is approved or unless supplemental limits are approved, the $DCGL_{EMC}$ for transfer of surface contaminated property will be three times the $DCGL_W$ and data will not be averaged over more than 1 m^2 as dictated by DOE Order 5400.5. Table 4 highlights the similarities and/or differences between title transfer and leasing protocols for DCGL application.

Table 4. DCGL Application Summary

Title Transfer	Lease
The $DCGL_W$ is applied to the average across the entire survey unit and the $DCGL_{EMC}$ is calculated as $DCGL_W \cdot (100/A_{hs})^{0.5}$ only for soil or water concentrations. For surface contamination, the $DCGL_W$ is applied to the average across only 1 m^2 and the $DCGL_{EMC}$ is calculated as $DCGL_W \cdot 3$.	The $DCGL_W$ is applied to the average across the entire survey unit and the $DCGL_{EMC}$ is calculated as $DCGL_W \cdot (100/A_{hs})^{0.5}$.

The $DCGL_{EMC}$ is used to trigger further investigation of a portion of the survey unit. Any measurement from the survey unit will be considered elevated if it exceeds the $DCGL_{EMC}$. The elevated measurement alone does not indicate that the survey unit fails to meet the criteria, only that further investigation will be necessary to determine the actual extent and concentration level of the specific elevated area. This information may be used with further modeling to ensure that the dose and risk criteria have been met.

2.3 IDENTIFICATION OF INPUTS TO THE DECISION

Once the decision statements are established it is necessary to determine the information that will need to be collected. Three types of data may be collected, including 1) scanning measurements, 2) direct field measurements, and 3) laboratory analysis of samples. These information inputs are discussed below.

2.3.1 Existing Characterization Data

Existing survey and sampling data will be used, if available. Additional surveys and sampling for laboratory analyses may be needed before occupancy to verify that the radiological conditions have not changed since surveys were last performed. In addition, an estimate of the expected variability of the data is necessary before acceptable limits on decision errors and the number of measurements necessary to meet them can be established. Information from historical surveys, as well as air monitoring and waste characterization data, can be used in estimating the mean and standard deviation expected for residual radioactivity in a survey unit. Experience and scientific judgement will be used to estimate the expected measurement variability.

Historical data will be used to identify the potential contaminants of concern for the survey unit. Isotopic information is important to determine the applicable limits and the appropriate survey methods and surrogate measurement-to-radioisotope relationships. Other radiation sources, such as x-ray machines, and sealed sources identified during facility walkdowns, record reviews, and discussions with knowledgeable individuals will be addressed in individual survey plans.

The Reindustrialization Program has relied on historical data to characterize the expected radionuclide ratios for various facilities when setting DCGLs. Facility-specific historical characterization data have been used (when available) for planning purposes, and sampling and analysis have been performed to confirm or establish the ratios prior to risk analysis. Process facility averages are not used for developing plant-wide DCGLs, except for areas remotely located from the main process buildings, and, therefore, do not contain sufficient contamination for determination of statistically significant ratios.

Most of the facilities that have become available to date for title transfer or lease have been located at the East Tennessee Technology Park (ETTP). Therefore, the focus of this document has been on designing radiological surveys and sampling programs at ETTP. The following section documenting the process history at ETTP serves as an example of how process history affects radionuclide ratios and how that subsequently affects the DCGLs. The process history for potential leasable/releasable property at other ORR sites is not discussed in detail in this document. When warranted, a similar evaluation will be conducted for other sites and site-specific radionuclide ratios will be documented in the appropriate survey plans to ensure that the DCGLs are suitably tailored for each location.

2.3.1.1 ETTP Site Process History and Expected Radionuclide Ratios

The contamination at ETTP site is almost entirely from past gaseous diffusion enrichment operations. Therefore, the primary radiological contaminants are uranium isotopes and their early in-growth daughters.

During the more than 40 years of operation at the Oak Ridge Gaseous Diffusion Plant (formerly known as the K-25 Site, now ETTP), thousands of tons of uranium were processed through the diffusion cascades. The vast majority of the uranium had been extracted and purified from ore, but some was recycled material obtained from spent reactor fuel. Other types of activities were also conducted periodically on-site but, in general, involved the same radionuclides. Since 1984, the site has been used primarily for the storing and on-site processing of waste, including wastes from other DOE facilities.

Unlike virgin feed material, material recycled from reprocessed reactor fuels contained trace quantities of fission products and TRU elements. Most of these impurities were removed during chemical processing

of the fuels prior to sending the material to the gaseous diffusion plants for recycle. Because the fluorinated compounds or the elements in question have limited volatility, much of the impure activity initially present either remained in the feed cylinders or was deposited in the cascade equipment close to the feed point. Trace quantities passed through both of these chemical and physical separations to contaminate the diffusion cascades and feed and tails facilities.

On an activity basis, the principal radionuclides expected to pass through chemical processing to contaminate the recycled uranium obtained from spent reactor fuel are the TRU radionuclides produced in highest abundance and with moderate to long half-lives: ^{237}Np , ^{238}Pu , ^{239}Pu , ^{240}Pu , and ^{241}Am . In addition, certain fission and activation products may form volatile compounds in the fluorination process: ^{99}Tc , ^{106}Ru , ^{134}Cs , and ^{137}Cs . Because of its long half-life and chemistry similar to uranium, ^{99}Tc is the only fission or activation product contamination that has been detected in concentrations that could affect public health.

Past operations at ETTP were primarily in support of the former gaseous diffusion enrichment process or the development of similar processes using gas centrifuges (GCEP) and lasers (AVLIS). As pieces of equipment such as motors, converters, compressors, and cylinders were moved around the site to be cleaned, repaired, or tested, varying amounts of radionuclides may have contaminated surfaces. Based on this, the contamination found in most places at ETTP should have an isotopic distribution similar to the main process buildings. A study of the isotopic distributions in the main process buildings is documented in K/HS-570, *Assessment of Accessible Contamination at the K-25 Site Phase 3 Report: Cumulative Analytical Results*. The results of calculating the weighted average U:TRU activity ratio show the ratio was greater than 1000:1 for every process building and the weighted average U: Tc activity ratio was greater than 1:1 for most samples taken from process areas. The significance of these ratios is discussed in Sect. 2.3.2.

2.3.2 Survey Unit-Specific DCGLs

Once the isotopic distribution is known, DCGLs can be established for the mixture of radionuclides. Because survey techniques often do not measure each radionuclide's concentration directly, a surrogate measurement is often used that can be related to the different radionuclides based on the established isotopic distribution. DCGLs can be established in terms of this surrogate measurement. For example, for uranium and its decay series, either gross alpha or gross beta surface activity measurements can be used as surrogates. In practice, both gross alpha and gross beta measurements are usually recorded. Beta surface activity measurements are generally preferred over alpha surface measurements for comparison to dose and risk limits because alpha radiation may be significantly attenuated by rough, porous, and dirty surfaces. However, the relationship of beta and alpha emissions from the decay chain must be determined, considering the degree of equilibrium and the enrichment/depletion of the uranium isotopes. Gross alpha measurements may be more sensitive when monitoring for highly enriched uranium because the alpha to beta activity ratio is large. The ratio of each radioisotope in the distribution to the measured gross beta activity can then be established and/or a DCGL can be established that relates directly to the surrogate measurement.

Exposure rate measurements may also be performed as a surrogate because they are directly related to the external exposure pathway, thereby reducing the amount of pathway modeling required. Further protocols for survey instrument selection and survey techniques are found the Appendix.

The following section relative to ETTP serves as an example of setting survey-specific DCGLs. Survey unit-specific DCGLs will be developed for other sites based on site-specific process knowledge and will be documented in the appropriate survey, sampling, and analysis plans.

2.3.2.1 Survey Unit Specific DCGLs at ETTP

It has been documented¹ that the uranium contamination limits of 1000 dpm/100 cm² removable and 5000 dpm/100 cm² total (fixed plus removable) are the appropriate surface contamination limits for most areas at ETTP, and that the limits for other potential radiological contaminants will be met if the uranium limits are met. Therefore, these will be the surface contamination DCGLs for most areas of ETTP. Some processes, such as the use of traps and settling of sludge in ponds or tanks, may have concentrated some radioisotopes preferentially to others, and some areas have been designated as transuranic areas where the U:TRU ratio is known to be less than 50:1 or where the U:Tc ratio is known to be less than 1:10. Samples will be collected from areas of significant contamination for isotopic analysis in order to establish/confirm radionuclide ratios for specific locations. Special attention will be given to process areas where U:TRU ratios may be lower than the plant averages. When low levels of contamination prevent establishment of statistically significant ratios, a conservative isotopic ratio will be used. If isotopic analysis of samples taken from the survey unit indicate the need, modified DCGLs based on the measured radionuclide ratios may be used (with DOE, EPA, and TDEC concurrence) to ensure that all decision criteria are met. This may be done by acceptance of alternate categories for contamination limits, performance of a sum of fractions calculation, or derivation of DCGLs from site-specific modeling. If default values are used in lieu of actual data to determine the radionuclide ratios and DCGLs, their justification will be fully documented in the survey plan. This approach adequately protects against unexpectedly low U:TRU ratios. Release of personal property must also meet site requirements and be approved by the DOE contractor responsible for site radiological control.

2.3.3 Classification of Survey Units

The scope and extent of measurements required for each survey will be based on a graded approach. The approach will depend on both the levels of contamination expected from site operating history and previous survey data for the area, according to the class definitions presented in MARSSIM.

The survey units are classified as either nonimpacted areas or impacted areas. Nonimpacted areas have no potential for residual contamination. Impacted areas are further divided into one of three classifications:

- *Class 1 Areas:* Areas containing locations where, prior to remediation, the concentrations of residual radioactivity may have exceeded the DCGL_w.
- *Class 2 Areas:* Areas containing no locations where, prior to remediation, the concentrations of residual radioactivity may have exceeded the DCGL_w.
- *Class 3 Areas:* Areas with a low probability of containing any locations with residual radioactivity.

Personal property will be classified by the type of area(s) in which it has been historically located. Title transfer (free release) of personal property may have requirements as dictated by the site radiological control procedures that are in addition to those listed below for real property.

2.3.4 Survey Protocol for Class 3 Areas

The survey protocol for Class 3 Areas is intended to collect data for offices and other areas that have been maintained as clean or free of radiological contamination. These areas are not expected to contain residual levels of radioactivity. The majority of the facilities proposed for title transfer are Class 3. The

¹ Rucker, T. L., *Isotopic Distribution Contaminants Found at the U.S. Department of Energy Gaseous Diffusion Plants*, Science Applications International Corporation, October 29, 1999.

survey provides assurance that these areas are indeed clean and do not require radiological controls. The data will also be used to evaluate the need for performing a risk analysis prior to title transfer or lease. The survey measurements for surface activity will consist of a combination of surface scans, direct measurements, measurements of removable activity, and dose measurements if previous data is insufficient to verify that the area is clean.

Any contamination detected in Class 3 areas would be incidental to the work performed in the area. Contamination of these areas could only be caused by tracking in contamination from other areas or transfer from contaminated tools or other items brought into the area. Therefore, scanning surveys with locations based on professional judgement will be adequate to identify the presence of any activity that would be detectable above background. Survey of 100% of the floor, walls, and office furniture will not be necessary if levels of activity distinguishable from background are not found in these scanning surveys (see Appendix, Section III, for definition of distinguishable from background).

Scanning surveys of the entrances, primary traffic areas, and primary work surfaces in each room or facility will be performed. A minimum of 10% of the floor and work surfaces will be scanned. Scanning of walls and ceilings will be based on visual inspection and professional judgement. The scanning will be performed with a floor monitor at each entrance and in primary traffic areas. Hand-held survey instruments may be used in place of the floor monitor, if appropriate. In addition, computerized, motorized automatic scanning instrumentation may be used for the floor scans. Alpha and beta-gamma scanning with hand-held survey instruments will be performed at each primary work surface location (e.g., desks or counter tops) and on tools or any equipment that may have inadvertently been contaminated. A dose rate scan will also be made using a tissue-equivalent micro rem (μrem) meter to search for elevated areas of external dose rate. For exterior areas (e.g., soil, gravel, paved areas) and interior areas that have a potential for holding activity that would be difficult to detect by alpha and beta/gamma scans (e.g., drains, floor cracks/joints/penetrations, wall/floor interfaces), a scan will be performed using a sodium iodide (NaI) meter.

Scanning is performed only to identify any areas of elevated activity distinguishable from background (see Sect. 2.3.9). If any elevated activity levels are found by any of the scanning surveys, a direct measurement (timed count) at the location of the highest activity will be recorded for both alpha and beta-gamma activity unless a computerized, motorized scanning instrument is used. A smear sample will also be collected from that location, if it is not on soil, by taking a 100-cm² swipe of the area for removable contamination and counting on a smear counter.

Identification of activity levels in excess of 25% of the DCGL will require reclassification of all or part of the area as Class 2 or Class 1 and will require further surveys as specified below. Reclassification of only part of an area will only be performed when additional data or newly discovered process knowledge provides a sound basis for redefining the survey units and sizes (i.e., additional data is obtained to define the size of the elevated area). The data used must be in addition to the data obtained from the number of samples prescribed by the initial survey; otherwise, the entire survey unit will be reclassified.

If no elevated activity above background levels is found by any of the scanning surveys, dose rate measurements will be made, at a minimum, in the center of each survey unit at 1 m above the floor. In addition, at minimum, a single direct measurement (timed count) will be recorded for both alpha and beta-gamma activity. Further fixed measurements will not be required for leases because the scanning methodology is expected to provide an overall probability of detecting contamination at the DCGL of greater than 95% and because no statistical test will be performed for Class 3 areas. When the property is to undergo title transfer (free release), an additional number of static measurements will be made at random locations. The number of samples will be determined based on historical data and the statistical tables found in MARSSIM Sect. 5.5.2. Alternatively, the equations found in MARSSIM that the tables are based on can be used. Table 5 highlights the similarities and/or differences between title transfer and leasing protocols for Class 3 survey units.

Table 5. Class 3 Survey Requirements Summary

Title Transfer	Lease
A minimum of 10% of the floor and work surfaces will be scanned.	A minimum of 10% of the floor and work surfaces will be scanned.
A static measurement will be made at the highest scan location or in the center of the survey unit if no elevated areas are found during the scan.	A static measurement will be made at the highest scan location or in the center of the room if no elevated areas are found during the scan.
A number of additional static measurements will be made at random locations. The number is based on historical data and the statistical tables found in MARSSIM Section 5.5.2.	No additional measurements will be made.

2.3.5 Survey Protocol for Class 2 Areas

The purpose of this type of survey is to collect data for facilities and areas that have known or suspected residual levels of radioactivity that do not exceed the DCGL. Some of the facilities proposed for title transfer will be in this category. The survey measurements for surface activity will consist of a combination of surface scans, direct measurements, measurements of removable activity, and dose measurements, if previous data are insufficient.

Scanning surveys will be performed in all accessible areas in the survey unit. For each survey unit, a scanning survey will be performed for alpha and beta-gamma contamination to identify the presence of any elevated activity levels. To support a lease, 10% to 100% (based on operating history, visual observation, and the previous survey results' proximity to the DCGL) of the accessible floor area in each survey unit will be scanned using a floor monitor. As a guide, the percentage of the scan coverage should be equal to or greater than the percentage of the DCGL that there is confidence that the activity concentrations are less than or equal to based on operating history, visual observation, and previous survey results. For example, if previous data shows that all results are up to but less than 50% of the DCGL, a minimum of 50% of the floor surface should be scanned. Additionally, scanning based on professional judgement may be performed to focus on areas with the highest probability of elevated activity. For title transfer, 100% of the accessible floor area in each survey unit will be scanned using a floor monitor. In addition, computerized, motorized, automatic scanning instrumentation may be used for the floor scans. Hand-held survey instruments may be used if it is not practical to use a floor monitor because of obstructions or set up time. For exterior areas (e.g., soil, gravel, paved areas) and interior areas that have a potential for holding activity that would be difficult to detect by alpha and beta/gamma scans (e.g., drains, floor cracks/joints/penetrations, wall/floor interfaces), a scan will be performed using a sodium iodide (NaI) meter.

To support a lease, measurements will not be taken in confined spaces or areas with asbestos-containing materials, such as attics, since these areas would likely be excluded from the lease footprint and/or controlled by lease restrictions. For title transfer (i.e., free release), scanning surveys will be performed in all areas in the survey unit, including confined spaces or areas with asbestos-containing materials, such as attics.

Because it is expected that most of the contamination in a building will be on the floor; 10% to 100% scanning will be performed to support title transfer on all wall surfaces, ceilings, and other overhead surfaces. The percentage again will be based on operating history, visual observation, and the previous survey results' proximity to the DCGL as indicated by the guidance above. When the property is to be leased, 10% to 100% scanning will only be performed on lower walls (up to 8 ft). Again, the percentage will be based on same parameters as for title transfer above. Only 10% to 50% of upper walls, ceilings, and other overhead surfaces will be scanned. Again, the percentage will be based on same parameters as above. A dose rate scan will also

be made using a µrem meter to search for elevated areas of external dose rate. If dose rates above background are detected, direct alpha and beta-gamma scans will also be made of the elevated areas.

The scanning is performed only to identify the areas of highest elevated activity. For title transfer (i.e., free release), smears and direct readings (timed count) will be obtained from all areas with results greater than 25% of the DCGL at locations of the highest contamination as indicated by the scanning surveys for each horizontal and vertical surface. For property lease, smears and direct readings (timed count) will be obtained from areas with the five highest levels of contamination detected by the scanning surveys for each horizontal and vertical surface. For soil contamination areas, samples will also be collected for laboratory analysis from each of these areas.

Identification of activity levels in excess of the DCGL will require reclassification to Class 1 of all or part of the area and will require further surveys as specified below. Reclassification of only part of the area will only be performed when additional data or newly discovered process knowledge provides a sound basis for redefining the survey units and sizes. The data used must be in addition to the data collected during the initial survey; otherwise, the entire survey unit will be reclassified.

In the absence of any results greater than 25% of the guideline on any surface scan, smears and direct alpha and beta-gamma measurements will be taken, at minimum, in the middle of the survey unit for each surface, including walls and ceilings. A dose rate measurement will also be taken, at a minimum, in the middle of each survey unit at 1 m above the floor. For title transfer (i.e., free release), an additional number of static measurements will be made at systematic points defined by a grid starting at a random location. The number of samples is determined based on historical data and the statistical tables found in MARSSIM Sect. 5.5.2. Alternatively, the equations found in MARSSIM (that the tables are based on) can be used. Table 6 highlights the similarities and/or differences between title transfer and leasing protocols for Class 2 survey units.

Table 6. Class 2 Survey Requirements Summary

Title Transfer	Lease
100% of the floor area in each survey unit will be scanned, including confined spaces or areas with asbestos containing materials, such as attics.	10% to 100% of the <u>accessible</u> floor area in each survey unit will be scanned. No measurements will be made in confined spaces or areas with asbestos-containing materials.
10% to 100%* scanning will be performed on <u>all</u> wall surfaces, ceilings, and other overhead surfaces.	10% to 100%* scanning will be performed on lower walls (up to 8 ft). 10 to 50% of upper walls, ceilings, and other overhead surfaces will be scanned.
Smears and direct readings (timed count) will be obtained from locations of the highest contamination for <u>all areas with results greater than 25% of the DCGL</u> as indicated by the scanning surveys for each horizontal and vertical surface.	Smears and direct readings (timed count) will be obtained from areas with the five highest levels of contamination detected by the scanning surveys for each horizontal and vertical surface.
An additional number of static measurements will be made at systematic points defined by a grid starting at a random location. The number of samples is determined based on historical data and the statistical tables found in MARSSIM Sect. 5.5.2.	No additional measurements will be made.

*The actual percentage will be based on operating history, visual observation, and the previous survey results' proximity to the DCGL.

2.3.6 Survey Protocol for Class 1 Areas

The purpose of this type of survey is to collect data for facilities that have historical or expected residual levels of radioactivity above the DCGL. A limited number of the facilities proposed for title transfer may be Class 1. Prior to title transfer, however, they will have been cleaned up pursuant to CERCLA and/or Resource Conservation and Recovery Act (RCRA) requirements. As an example, in the case of the Three Building D&D and Recycle Project (K-29, K-31, K-33), surveys performed under CERCLA will be used to support title transfer. Those surveys will have met these or other negotiated requirements. The survey measurements for surface activity will consist of a combination of surface scans, direct measurements, measurements of removable activity, and dose measurements if previous data is insufficient.

A scanning survey will be performed in all accessible areas in the survey unit for alpha and beta-gamma radiation to identify the presence of any elevated activity levels. For title transfer (i.e., free release), 100% of the floor area will be scanned using either a floor monitor or a computerized, motorized scanning instrument. To support lease, 100% of only the accessible floor area in each survey unit will be scanned. Hand-held survey instruments may be used in place of a floor monitor if it is practical to do so (e.g., because of obstructions or set up time). For exterior areas (e.g., soil, gravel, paved areas) and interior areas that have a potential for holding activity that would be difficult to detect by alpha and beta/gamma scans (e.g., drains, floor cracks/joints/penetrations, wall/floor interfaces), a scan will be performed using a NaI meter. A dose rate scan will also be made using a μ rem meter to search for elevated areas of external dose rate.

It is expected that most of the contamination in a building will be on the floor; therefore, floors, walls, ceilings, and other overhead surfaces may be classified separately as separate survey units. If they are known to also contain areas of activity greater than the $DCGL_w$, their classification as a separate survey unit is not necessary and 100% of the accessible surface will be scanned.

For property lease, no measurements will be made in confined spaces or areas with asbestos-containing materials, such as attics, since these areas would likely be excluded from the lease footprint and/or access-controlled by lease restriction. For title transfer (i.e., free release), scanning surveys will be performed in all areas in the survey unit, including confined spaces or areas with asbestos containing materials.

Smears and direct readings (timed count) will be obtained from areas with levels of contamination greater than the DCGL detected by the scanning surveys. In addition, smears, direct alpha and beta-gamma measurements, and dose rate measurements will be taken at systematic points defined by a grid starting at a random location. The number of samples will be determined based on historical data and the statistical tables found in MARSSIM Sect. 5.5.2. Alternatively, the equations found in MARSSIM can be also used. A dose rate measurement will be taken, at minimum, in the middle of each survey unit at 1 m above the floor. It should be noted that routine survey data is usually available for Class 1 survey units. Additional surveys will only be performed to supplement the existing data as required. Table 7 highlights the similarities and/or differences between title transfer and leasing protocols for Class 1 survey units.

Table 7. Class 1 Survey Requirements Summary

Title Transfer	Lease
100% of the floor area in each survey unit will be scanned including confined spaces or areas with asbestos containing materials.	100% of the <u>accessible</u> floor area in each survey unit will be scanned. No measurements will be made in confined spaces or areas with asbestos-containing materials.
Walls and ceilings will be classified separately.	Walls and ceilings will be classified separately.
Smears and direct readings (timed count) will be obtained from areas with levels of contamination greater than the DCGL that are detected by the scanning surveys.	Smears and direct readings (timed count) will be obtained from areas with levels of contamination greater than the DCGL that are detected by the scanning surveys.
An additional number of static measurements are made at systematic points defined by a grid starting at a random location. The number of samples is determined based on historical data and the statistical tables found in MARSSIM Sect. 5.5.2.	An additional number of static measurements are made at systematic points defined by a grid starting at a random location. The number of samples is determined based on historical data and the statistical tables found in MARSSIM Sect. 5.5.2.

2.3.7 Confirmation

An additional survey of a facility may be conducted at the time of title transfer or lease if the building was not controlled in a manner to ensure that conditions have not changed between the time of the survey and disposition. In these cases, a scanning survey will be performed for alpha and beta-gamma contamination to identify the absence of any elevated activity levels. Ten percent (10%) of the accessible floor area in a building will be scanned using either a floor monitor or a computerized, motorized scanning instrument. If elevated activity is found, a direct measurement (timed count) will be performed and a smear sample will be collected at the location of the highest activity level.

If direct measurements and smear activity are within 25% of the previously recorded reading for the grid or room, the location will be considered to be in the same condition as before, and the risk will remain the same.

The State of Tennessee or EPA radiological staff may conduct additional surveys if independent verification is desired.

2.3.8 Sampling and Laboratory Analysis

It is anticipated that limited sampling and laboratory analysis will be necessary to confirm the established ratios for the radionuclides discussed above, further define the areal extent of potential contamination, and/or determine maximum contamination levels within an area. Sampling and analysis plans will be prepared for each facility, as necessary, and will be reviewed by the regulators prior to implementation of the plan.

For indoor areas, samples may be collected at locations where anomalous levels of residual contamination are observed or suspected (e.g., where floor drains/sumps may have collected contaminants if they have not been sealed). This determination will be based on historical knowledge and professional judgement.

Soil samples may be taken in outdoors in areas where soil data is not available, or when interior surveys indicate contamination may have been deposited outdoors, such as in a drain. An historical investigation of the study area will be conducted and will include review of past/present operations and existing data to identify any potentially contaminated area(s). For title transfer or lease of buildings with small grassy areas, surface soil samples may be collected in selected locations to determine if contamination exists. The decision of whether or not to collect samples will be determined on a case-by-case basis and will be based on historical process knowledge and existing data. This decision will have the concurrence of the regulators. Analytical sample results will be compared to site background (if applicable) and then screened against the 10^{-6} risk PRG. The results will be used with the statistical rules from Sect. 2.5 of this document to see if additional sampling is necessary to meet the decision objectives.

If the survey unit is within a large open space (e.g., parking lots or large parcels of land), an historical investigation to determine use and spill history will be conducted. (This is typically prepared for the EBS or BEAR.) Based on the results of this investigation, a more rigorous sampling strategy may be employed to determine if contamination exists. In addition, walkover surveys using a NaI detector will be performed to look for elevated areas of contamination. Biased samples will be collected for laboratory analysis from any location that has a NaI survey reading greater than three times the established background. The basis for the "three times rule" stems from the fact that natural backgrounds vary by up to a factor of three depending on geology, topography, and other geometric factors. If statistical sampling for laboratory analyses is required for these types of survey units, then statistical sampling at systematic points defined by a grid starting at a random location may be performed. The number of samples will be based on historical data and the statistical tables found in MARSSIM Sect. 5.5.2. The samples will be analyzed for all radionuclides appropriate for the site based on process knowledge. The following section provides the analysis scheme appropriate for ETTP as an example.

2.3.8.1 Analysis Scheme for ETTP

All samples will be analyzed for a base list of analytes, including isotopic uranium, isotopic thorium, technetium, a gamma scan, and a total activity (or gross alpha/beta) measurement. In addition, for the biased samples, isotopic plutonium, ^{237}Np , and ^{241}Am will be added to the analyte list because their activity is more likely detectable in elevated activity samples. All systematic samples will be analyzed for the base list of analytes above plus 10% will be selected for transuranic analyses (with locations based on the highest NaI readings of the samples as taken in-situ) to check for unexpected ratios of transuranics. Transuranic analyses may also be added to the base list for all systematic samples based on specific process knowledge of higher levels of transuranics. Analysis for other radionuclides, such as ^{90}Sr , for sites associated with the Oak Ridge National Laboratory operations or waste may be appropriate. The specific radionuclides to be analyzed will be listed in a facility-specific Sampling and Analysis Plan (SAP).

2.3.9 Background Determination

Many of the radionuclides found on the ORR have natural background concentrations. Therefore, background subtraction will be required for both direct field measurements and laboratory analyses. Some comparison to background levels will also be required for the scanning because only a gross signal will be measured. Topographical considerations will be weighed for this background comparison. Furthermore, material specific backgrounds may be necessary for material such as tile, brick, and cinderblock because these materials contain elevated levels of naturally occurring radionuclides. Comparison with the established background soil values for East Tennessee will be made for the ORR. If new background values are established or accepted by EPA and TDEC, they will be used by to support title transfers and leases.

2.4 STUDY BOUNDARIES

A survey unit is a physical area consisting of structures or land areas of specified size and shape for which a decision will be made concerning use, risk, or release. Defining spatial and temporal boundaries helps ensure that the samples taken are representative of the survey unit. Since statistical methods will be used to define the number of samples taken and extent of surveys performed, it is important to define survey units so that the variability of concentrations is minimized. Furthermore, knowledge of the concentrations of residual radioactivity prior to remediation is used to define the type of statistical sampling and the extent of coverage for scanning that will be used for each survey unit.

The site will be divided into survey units that have the potential for relatively uniformly distributed areas of contamination, a common history or other characteristics, or are naturally distinguishable from other portions of the site. An historical assessment should be performed to gather process knowledge information and data collected during previous surveys so that proper survey unit identification and classification can be performed.

2.4.1 Spatial Boundaries

Survey units should not include areas that have different classifications. In addition, the survey unit's characteristics should be generally consistent with the exposure pathway modeling that is used to determine the dose or risk from the radionuclide concentrations. Indoor areas may be subdivided into survey units by using existing boundaries that limit exposure such as rooms or walls separating different areas. Indoor areas may also be subdivided into several survey units of different classification by separating surfaces with different exposure potential, such as separating floors and lower walls from upper walls and ceilings or subdividing a large warehouse based on floor area. A survey unit should be contiguous.

The survey units should be limited in size based on classification, exposure pathway modeling assumption, and site-specific conditions. Table 8 presents the sizes MARSSIM suggests for survey units.

Table 8. Suggested Maximum Sizes for Survey Units

Class	Suggested Size	
	Building/Structure	Land
1	< 100 m ² floor area	< 2,000 m ²
2	100 to 1,000 m ²	2,000 to 10,000 m ²
3	no limit	no limit

The limitation on maximum survey size is intended to ensure that an adequate number of data points are used for each area. However, larger survey unit sizes can be used to match the exposure assumptions of the pathway modeling. The rationale should be developed using the DQO process and documented in the survey and/or sampling plan.

2.4.2 Temporal Boundaries

Work performed in the survey unit after the survey is made could alter the conditions of the unit. An additional, targeted survey of the facility should be conducted prior to title transfer or lease if suspect activities have occurred.

2.4.3 Reference Coordinates

Reference coordinate systems will be established for each survey unit to facilitate selection of measurement/sampling locations and to provide a mechanism for referencing the measurements so that they can be relocated. A site diagram will be prepared showing each survey unit.

2.4.4 Sampling Grids

The probability sampling (less than 100%) performed by static field measurements will be systematic sampling on a systematic rectangular or triangular grid with a random start for Class 1 and Class 2 areas and simple random sampling for Class 3 areas. It is anticipated that only these measurements will be used in conducting the nonparametric statistical tests for title transfer. However, results from scanning, direct field measurements, and laboratory analysis of samples may be used for elevated measurement comparison against an upper limit value.

If it is determined that further surveys and analyses are necessary to reliably determine the radionuclide ratios, biased sampling will be conducted. The sampling will be to biased toward areas of higher contamination. This will be done in order to 1) weight the radionuclide ratios by the total activity, and 2) obtain enough activity to accurately determine the radionuclide ratios.

2.5 THE DECISION RULE

A decision rule relates the concentration of residual radioactivity in the survey unit to the release criterion so that decisions can be made based on the results of the final status survey. The decision rule proposed for these surveys consists of a statistical test and an elevated measurement comparison. The decisions are made as follows:

- If all of the measurements are below the $DCGL_w$, the survey unit meets the criteria that no radiological controls are necessary.
- If the average of the measurements is above the $DCGL_w$, the survey unit does not meet the criteria.
- When the average is below the $DCGL_w$ and some of the measurements are above the $DCGL_w$, a statistical test and the elevated measurement comparison will be used to determine if the release criteria have been met.

The following sections define the parameters that will be used along with the tables found in NUREG-1575 (MARSSIM) and NUREG-1505, *A Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys*, for determining the number of samples (direct field measurements) that will be necessary for the statistical test to be valid. The statistical tests and rules referred to in this section will only be performed when the property is to undergo title transfer (i.e., free release). However, the statistical rules are also used to define the number of systematic samples necessary to perform a risk assessment for lease purposes. Table 9 highlights the similarities and/or differences between title transfer and leasing protocols for statistical tests and rules use.

Table 9. Statistical Tests and Rules Use Summary

Title Transfer	Lease
The statistical tests and rules referred to in this section will be performed to determine compliance to the release criteria.	The statistical rules will only be used to define the number of systematic samples needed to perform the required risk assessments.

The input parameters for the decision rule may vary from one study area to another depending on the type of contamination expected to be present and how close background levels are to the DCGL. The following sections provide input parameters and give statistical rules that are appropriate for survey measurements made at most buildings at ETPP because the expected DCGLs are significantly higher than background levels and detection limits. When the DCGLs are close to the detection limits as they may be for soil DCGLs and for TRU areas, different input parameters may need to be chosen and will be defined in the site-specific survey and/or SAP. The input parameters below apply to all sites where noted.

2.5.1 The Statistical Test for ETPP Buildings

Many of the radionuclides at the site have natural background concentrations. In addition, gross survey measurements will be made. These are two conditions that might require the use of a statistical test that makes a comparison to background levels. However, the background concentrations are much lower than the DCGL established for gross measurements. Because it is expected that statistical tests will only be performed on these gross field measurements for buildings, only the use of the Sign Test for statistical analysis is anticipated. This is because the Sign test does not use background data. In addition, because it is expected that the variability in the data will be small relative to the $DCGL_w$, the following scenario has been chosen for the statistical test:

The Null Hypothesis, H_0 = the survey unit does not meet the criteria,
The Alternative Hypothesis, H_a = the survey unit meets the criteria.

The null hypothesis is the default decision unless there is statistical confidence that the alternative hypothesis is true. Although this scenario may require additional action (i.e., decontamination) prior to release when it is not strictly necessary, this is considered acceptable for the following reasons: 1) the contamination below the $DCGL_w$ is expected to be easily measurable, 2) additional remediation may still have some benefit in the form of reduced radiation exposure, and 3) releasing a survey unit that really should be remediated further is a less tolerable mistake.

2.5.2 Elevated Measurement Comparison for All Sites

The decision rule for the elevated measurement comparison (EMC) is a two-stage process. In the first stage, areas are flagged as potentially elevated at the specified investigation levels. In the second stage, the actual average concentration over the actual extent of elevated area is compared to the release criteria. The level at which measurements should be flagged depends on the unit classification. For Class 1 survey units, areas will be flagged if the direct measurement or scanning measurement indicates concentrations above the $DCGL_{EMC}$. For Class 2 survey units, areas will be flagged if the direct field measurement or scanning measurement indicates concentrations above the $DCGL_w$. For Class 3 survey units, areas will be flagged if the direct measurement indicates concentrations above one half of the $DCGL_w$ or the scanning measurement indicates concentrations above the minimum detectable concentration (MDC).

2.5.3 Limits on Decision Errors

2.5.3.1 Measurement Technique Detection Capabilities for ETP Buildings

Based on NUREG-1507, *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Condition*, it is expected that concentrations of 65 dpm/100 cm² can be detected with 95% confidence for alpha emitters measured with a ZnS scintillation detector and a 1 minute static count time. The detection limit increases to approximately 300-dpm/100 cm² in the presence of reasonable amounts of moisture, dust, or paint. Also, based on NUREG-1507, it is expected that concentrations of 1500 dpm/100 cm² can be detected with 95% confidence for ⁹⁹Tc measured with a GM detector and a 1-min static count time. The detection limit does not increase significantly in the presence of reasonable amounts of moisture, dust, or paint. These MDCs are only a fraction of the DCGL. Therefore, the measurement variability is expected to be small at the DCGL. If other survey instruments are used, the detection capability should be equivalent or better.

2.5.3.2 Type I and Type II Errors for All Sites

A Type I error is made when the null hypothesis is rejected when it is actually true, i.e., stating that the survey unit meets the release criteria when it actually does not. A Type II error is made when the null hypothesis is not rejected when it is false, i.e., stating that the area does not meet the release criteria when it actually does. The error rates are expressed as the probability that a survey unit passes when it should fail (α for this scenario) or fails when it should pass (β for this scenario). The number of grid points should be determined based on Table 5.5 of the MARSSIM guidance (or by using the underlying equations) using values of 0.05 for α and 0.10 for β . A relative shift of between 1 and 3 should be used if there is no existing data to calculate the actual standard deviation and the relative shift. This will provide a frequency of falsely concluding that the survey unit meets the DCGL only 5% of the time, while falsely concluding that the survey unit does not meet the DCGL only 10% of the time. Table 10 highlights the similarities of title transfer and leasing protocols for error rate parameters.

Table 10. Error Rate Parameters

Title Transfer	Lease
Use values of 0.05 for α , 0.10 for β .	Use values of 0.05 for α , 0.10 for β .

2.5.3.3 The Gray Region for ETP Buildings

A Lower Boundary of the Gray Region (LBGR) also has to be selected for the application of the statistical test. The LBGR is the concentration level below which further action (i.e., decontamination) is not reasonably achievable. It is used by the statistical test to define the level that above which false positive rates greater than those specified by the limits on decision errors are accepted. The LBGR is limited by the variability exhibited by the measurements and the decision errors chosen. Because the detection limits expected to be achieved by the direct field measurements are low relative to the DCGL_w, it is estimated that an LBGR equal to half of the DCGL_w can be achieved for survey measurements for this project. The concentration range between the LBGR and the DCGL defines the gray region of residual radioactivity concentrations in which the consequences of decision errors are relatively minor. For soil concentrations, an LBGR closer to the DCGL may be necessary due to isotope specific detection limits that are close to the DCGL.

2.6 OPTIMIZATION OF THE DESIGN

The DQO process is neither static nor sequential. This is because new information may continue to be gathered that should be incorporated into the planning process. Optimization of the survey will be performed by examining all factors that affect the decision errors and sample sizes so that costs and potential risks are balanced. This may include further evaluation of the $DCGL_W$, the $DCGL_{EMC}$, and the measurement standard deviation. The estimate of the measurement standard deviation will include both the uncertainty in the measurement process and any anticipated spatial and temporal concentration variations. As new information becomes available, it will be factored into the development of survey and sampling plans in an effort to optimize their design.

APPENDIX A
SUPPLEMENTAL PROTOCOLS FOR RADIOLOGICAL SURVEYS
AND SAMPLING FOR LABORATORY ANALYSES

I. SELECTION OF EQUIPMENT

A. Selection of Material and Equipment for Smear Measurements

The smears used will be cloth smears. Cloth smears will be used due to the better transfer characteristics of removable contamination to cloth. The swipes will be analyzed by counting on a Tennelec model LB5100 (gas proportional) automated smear counter or the Ludlum Model 2929 alpha/beta scaler/ratemeter, or equivalent.

B. Selection of Equipment for Contact Reading Measurements

Industry standard instruments will be selected based on the type of instrument that will be the most sensitive in accordance with recommendations as set forth in the *Health Physics Manual of Good Practices For Uranium Facilities*. The selection will also be based on the mix of radioisotopes, the types of monitoring to be performed, and the range of contamination levels requiring detection.

The *Health Physics Manual of Good Practices for Uranium Facilities* specifies that, in general, alpha instruments will be the most sensitive and effective. This is because background count rates are lower for alpha probes than for beta probes. However, this assumes that the uranium alpha activity is equal to or greater than the activity from the U-238 daughters, Pa-234m and Th-234. This is only the case for normal and enriched uranium. *It should be noted that this is not the case for depleted uranium, which is the primary form of uranium contamination at ETPP.* Therefore, both alpha and beta surveys will be performed unless it is known that contamination consists of only enriched uranium. Furthermore, areas that have a U: Tc ratio less than 1 will require both alpha and beta surveys to ensure that proper contamination controls are in place.

Instruments will be chosen that will meet a minimum detectable activity (MDA) of less than or equal to each appropriate total contamination limit. The DOE Draft Guidance: *Environmental Implementation Guide for Radiological Survey Procedures*, November 1992, provides approximate MDAs for various alpha and beta instrumentation and probe sizes for static integrated (1 minute) measurements.

Based on the selection criteria listed above, instruments equipped with alpha scintillation probes with a minimum probe width of 4.3 cm in the direction of scanning motion and a minimum open active area of 50 cm², a minimum detection efficiency of 10 %, and a maximum instrument background of 3 counts per minute for non-transuranic alpha surface contamination surveys should be selected for alpha surveys. Gas proportional alpha meters are used in identified transuranic (TRU) areas or areas where there is a potential for encountering TRU contamination.

For beta surveys, instruments equipped with beta-gamma pancake GM probes, a minimum detection efficiency of 18 %, and a maximum instrument background of 45 counts per minute (for non-strontium category beta-gamma surface contamination scanning) should be selected.

Additionally, a variety of specialized instruments such as gas proportional floor monitors may be used to supplement the stationary measurements.

II. QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENTS AND DATA COLLECTION

A. *Quantitative Limits and Ranges for Precision and Accuracy*

Smear Counting

During calibration, the Radiological Control Technician (RCT) will determine the sample count time necessary for the MDA to be less than or equal to each appropriate removable contamination limit criteria. A count time will be chosen to meet an MDA of a factor of 10 less than each appropriate removable contamination limit in order to provide reasonable statistical confidence at the level of the contamination limit, provided the time is less than or equal to 10 min. The MDA is the lowest practical activity that the instrument can be routinely distinguished from background (that will routinely be greater than the L_c as defined in the next section). It is defined by the activity that equates to the Detection Limit (L_d) count rate calculated by:

$$L_d = k^2/T_s + 2ks_b(1+T_b/T_s)^{0.5}$$

where: k = the confidence interval factor for one-tailed statistics (a value of 1.65 will be used for 95% confidence),

s_b = an estimate of the background count rate (R_b) standard deviation, i.e.: $s_b = (R_b/T_b)^{0.5}$

T_b = the background counting time, and

T_s = the sample counting time.

Contact Reading Measurements

Instruments should be chosen that will meet an MDA of a factor of 10 less than each appropriate site total contamination limit criteria for a static count of 1 min in order to provide reasonable statistical confidence at the level of the limit, if possible. The MDA will meet a factor of two less than the criteria at a minimum. Instruments will be coupled with scaler rate meters so that both timed counts and integrated count rates can be taken.

B. *Representativeness, Completeness, and Comparability*

Scanning will be done to detect and identify the location of elevated areas of contamination. Scanning will usually be carried out with the detector signal feeding into a ratemeter instrument with an audible output. When the count rate increases, the rate of movement of the detector will be decreased or stopped. If the increase in count rate is judged to be real and not a random variation in the background count rate, a static measurement will be performed. The ability to identify areas of slightly elevated radiation during surface scanning is dependent upon the surveyor's skill in recognizing an increase in the audible output of the instrument, which varies with ambient background levels. The detection capability of surface scanning is also dependent upon survey speed, size of elevated activity region, level of activity, and detector/surface distance. Because the time that the area of interest is under the probe varies, it is not practical to determine an MDA for scanning with any degree of confidence. However, the Department of Energy Draft Guidance: *Environmental Implementation Guide for Radiological Survey Procedures*, November 1992, provides guidance on the probability of detecting an area of contamination at a predetermined guideline and a known scan rate for various alpha and beta instrumentation and probe sizes. For alpha survey instrumentation with backgrounds ranging from <1 to 3 cpm, a single count will give a surveyor sufficient cause to stop and investigate further.

To ensure that significant radiological contamination is not missed in the survey, the RCT will perform total contamination surveys in the following manner:

1. The surface is scanned at a rate that does not exceed 1.5 in per second.
2. The probe is held approximately 0.25 inches from the surface, and the audible output of the instrument is monitored.
3. Whenever a count (for alpha) or an increase in count rate (for beta) occurs, the scanning is paused to determine if the count-rate is greater than the background.
4. If the count rate is determined to not be greater than random variation in background, the survey is continued in the manner described above.
5. If the count rate is determined to be greater than random variation in background, a timed 1-min count is performed.
6. If the result of the timed 1-min count is greater than the removable limits for the area, a smear sample of the area is obtained or the area is identified so it can be smeared at a later time.

Using this methodology for alpha scanning, the overall probability of detecting a 5000-dpm/100 cm² spot of contamination is greater than 95%.

III. DATA RECORDING

For both smear counting results and timed count contact reading measurements results, the data used for the determination of each MDA will also be used to determine a Critical (Decision) level (L_c). The L_c is used as the key determinant for whether a sample analysis result is distinguishable from background. The L_c is defined as

$$L_c = ks_b (1 + T_b/T_s)^{0.5}$$

The results of each sample analysis will be recorded in the following manner:

For all timed counting results, the actual result will be recorded. This recording technique is used because the data will be averaged. Any other recording method will bias the average. The practice of recording *No Elevated Activity Detected* or *<MDA* or similar practices will be avoided. However, results less than L_c should be flagged in some way (e.g., with a U) to indicate that it is not statistically distinguishable from background. If desired, a 95% confidence limit can be calculated for the measurement as ± 1.96 times the estimated standard deviation for the sample, i.e.:

$$R_s \pm 1.96s_s$$

where R_s = the sample result in the recording units,

1.96 = the 95% confidence interval factor for two-tailed statistics (in practice, 1.96 may be rounded to 2).

$s_s =$ an estimate of the sample standard deviation [i.e. $s_s = (R_b/T_b + R_s/T_s)^{0.5}$] converted to the recording units.

Special attention should be given to ensuring the correct building location descriptions and postings are recorded properly on the survey form. Comments should be added to explain any discrepancies.

IV. CALIBRATION AND PREVENTIVE MAINTENANCE PROCEDURES

A. Maintenance

To ensure that survey instrumentation is operating properly, maintenance is performed as follows:

- during routine calibration of the instrument (semi-annual),
- when the instrument has been dropped or damaged,
- whenever the instrument has been found to be outside the $\pm 20\%$ source response check range, and
- whenever conditions adverse to quality have been observed (e.g., the instrument is not responding to the source).

Maintenance includes checking the following functions:

- instrument batteries,
- meter zero,
- meter balance,
- operational high voltage,
- pulse testing the instrument,
- instrument's alarm set points, and
- the response of the instrument to a National Institute of Standards and Technology (NIST)-traceable source.

B. Calibration

Portable survey instrumentation will be calibrated as follows:

- in accordance with the requirements and recommendations as set forth in American National Standards Institute (ANSI), *Radiation Protection Instrumentation Test and Calibration*, ANSI N323-1978 and the requirements of 10 CFR 835;
- semi-annually in accordance with 10 CFR 835 and ANSI N323-1978.

Recalibration of portable survey instrumentation will be performed whenever the following occurs:

- repairs have been made to the instrument,
- modifications have been made to the instrument, or
- the instrument has been found to be "out-of-tolerance" in accordance with ANSI N323-1978.

C. QC Response Check (Source Checks)

RCTs will perform an instrument response check by using a source (appropriate for the range and energies of radiations expected to be measured) in accordance with ANSI N323-1978.

The RCTs tag the instrument *Out of Service* and send it back for recalibration if the instrument does not fall within $\pm 10\%$ of the value determined at the time of calibration with the NIST-traceable check source.

NOTE: The use of control charts can help identify trends and determine if "out-of-control" points are because of statistical fluctuations or shifts in response. If control charts are used, a control limit of $\pm 20\%$ may be used with a warning limit of $\pm 10\%$ for assessment of repetitive points. Recalibration will be performed if two successive points are outside the warning limits.

V. DATA SUMMARIZATION, VALIDATION, AND REPORTING

A. *Data Reduction and Evaluation*

Data collected during field activities will be evaluated by checking the procedures used and comparing the data to previous measurements. The Survey Team Leader and Quality Assurance Coordinator will be responsible for checking measurement results to ensure that field measurement and sampling protocols have been observed. These reviews will check the following:

- date and time of measurement or sample,
- proper use of sample tracking and labeling system,
- use of quality control criteria to reject or accept specific data,
- calibration and associated documentation, and
- chain-of-custody documentation.

Reviewers are responsible for ensuring that data-reduction calculations are documented and checked by qualified personnel. Written reports, including reduced and summarized data, will include the raw data in appendices when necessary. Specific calculations used for data reduction will also be included. Protocols used for data evaluation will meet or exceed those specified by Bechtel Jacobs Procedure EH-3510, *Handling and Reporting Environmental Data*.

B. *Reporting of Measurement Results*

All data is to be recorded and reported properly. The format and content of data reports will adhere to program needs, which include applicable DOE and regulatory agency reporting formats. All data shall be stored so that complete data packages can be subsequently assembled for regulatory agencies. The format for data presentation presented in NUREG/CR-5849, *Manual for Conducting Radiological Surveys in Support of License Termination*, will be used. Protocols used for data reporting will meet or exceed those specified by Bechtel Jacobs Procedure EH-3510, *Handling and Reporting Environmental Data*.

C. *Statistical Assessment of Data*

If the area is expected to be releasable from radiological control without further action, statistical treatment of data and comparison with guideline values will be performed using the Sign Test as described in Chapter 8 of the MARSSIM Guidance. Preliminary statistical methods may also be performed using the guidance found in NUREG/CR-5849, *Manual for Conducting Radiological Surveys in Support of License Termination*. In this case, data for each survey unit will be averaged and a standard deviation will be calculated. An upper 95% confidence limit on the mean will be calculated by the following equation:

$$\mu = \text{mean} + t_{\alpha} \frac{s_x}{\sqrt{n}}$$

where mean = the calculated mean or average of the measurement results,
 t_{α} = the 95% probability factor from *students t table* for n-1 degrees of freedom,
 s_x = the standard deviation of the measurement results,
 n = the number of individual data points used to determine the mean and standard deviation.

The value μ is compared to the guideline value; if μ is less than the guideline, the area being tested meets the guidance on average at the 95% confidence level. This means that the probability is less than 5% that μ will pass the test when the true mean activity level exceeds the guidance value.