1 INTRODUCTION AND OVERVIEW

1.1 Purpose and Scope of MARSAME

Large quantities of materials and equipment (M&E) potentially affected by radioactivity are present throughout the United States. The potential for residual radioactivity can come from use of source, byproduct, and special nuclear materials as well as naturally occurring radioactive material (NORM), naturally occurring and accelerator-produced radioactive materials (NARM) and technologically enhanced naturally occurring radioactive material (TENORM). This M&E may be commercial, research, education, or defense related. The M&E might be—

- Used or stored at sites and facilities licensed to handle radioactivity,
- Commercial products purposely containing radionuclides (e.g., smoke detectors),
- Commercial products incidentally containing radionuclides (e.g., phosphate fertilizers), or
- Associated with NARM and TENORM.

The owners of M&E potentially affected by radioactivity need to determine acceptable disposition options for M&E currently under their control. Industries or facilities sensitive to the presence of radioactivity need to evaluate the acceptability of M&E coming under their control. Regulatory agencies need to distinguish items in general commerce that are inherently radioactive from illicit trafficking of radioactive M&E.

This *Multi-Agency Radiation Survey and Assessment of Materials and Equipment* manual (MARSAME) is a supplement to the *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM). Like MARSSIM, MARSAME is a joint effort by the Department of Defense (DOD), Department of Energy (DOE), Environmental Protection Agency (EPA), and Nuclear Regulatory Commission (NRC). Information on MARSSIM can be found on the World Wide Web (MARSSIM 2002). MARSAME also incorporates information for measuring radioactivity from the *Multi-Agency Radiological Laboratory Analytical Protocols* manual (MARLAP 2004). MARSAME provides information on surveys where radiological control of M&E could be initiated, maintained, removed, or transferred (i.e., an M&E disposition) to another responsible party. In addition, MARSAME discusses the need for a graded approach to surveying M&E.

MARSAME provides technical information on approaches for planning, implementing, assessing, and documenting surveys to determine proper disposition of M&E. Release (including clearance) and interdiction are types of disposition options in MARSAME. Detailed descriptions of these disposition options are provided in Chapter 2.

Examples of M&E include metals, concrete, tools, equipment, piping, conduit, furniture, and dispersible bulk materials such as trash, rubble, roofing materials, and sludge. Liquids, gases, and solids stored in containers (e.g., drums of liquid, pressurized gas cylinders, containerized soil) are also included in the scope of this document.

Radionuclides or radioactivity on workers or members of the public are outside the scope of the document, as are liquid and gaseous effluent releases and real property (e.g., fixed buildings and structures, surface and subsurface soil remaining in place).
The purpose of this supplement is to provide information for the design and implementation of technically defensible surveys for disposition of M&E. MARSAME provides information on selecting and properly applying disposition survey strategies and selecting measurement methods. The data quality objectives (DQO) process is used for selecting the best disposition survey design based on the selected disposition option, action level, description of the M&E (e.g., size, accessibility, component materials), and description of the radioactivity (e.g., radionuclides, types of radiation, surficial versus volumetric activity). Detailed information on the DQO process can be found in EPA QA/G-4 (EPA 2006a), MARSSIM Appendix D, and MARLAP Appendix B.

This supplement describes a number of different approaches for performing technically defensible disposition surveys and provides information for optimizing survey designs. However, MARSAME does not represent the only acceptable approach to radiologically evaluate M&E. MARSAME describes a graded approach that the signatory agencies find acceptable and useful for most situations. The signatory agencies recognize that alternative approaches or modification of the MARSAME procedures may be appropriate or necessary for some situations. Nothing in MARSAME should be construed to prohibit the use of other appropriate procedures.

Disposition surveys may be performed as a single event or as part of a routine process. Single event disposition surveys are usually performed once in association with a specific project. Surveying a backhoe at the completion of a decommissioning project is one example of a single event disposition survey. Routine process disposition surveys are usually associated with ongoing tasks where similar surveys are performed repeatedly. One example of a routine process disposition survey would be a radiological survey of tools prior to removal from a controlled area at a nuclear facility. Both single event and routine process types of surveys are included in the scope of MARSAME.

The guidance in MARSAME is designed to incorporate existing survey methods whenever possible, while at the same time allowing the use of new and innovative survey techniques when appropriate. The use of previously established and accepted standard operating procedures (SOPs) as part of a standardized initial assessment (IA) is described in Section 2.6.1. The use of SOPs that document approved methods for performing disposition surveys along with assessing the results of these surveys can reduce the effort required to develop new survey designs, since the survey design effort was applied when the SOP was developed. MARSAME also allows consideration of innovative survey techniques through the modification of existing SOPs or development of new survey designs as described in Chapters 3, 4, and 5. Prior to implementation, existing SOPs should be evaluated to ensure they meet the survey design objectives.

MARSAME assumes the user has some historical knowledge of the M&E being investigated. The historical information is gathered during the initial assessment (IA) to determine acceptable disposition options (Chapter 2). The characteristics, history of prior use, and inherent radioactivity of the M&E are important when determining the appropriate disposition options.

The historical information is termed “process knowledge.” The role of process knowledge (discussed in Chapter 2) is important in providing information on the nature and amount of radioactivity that might be expected on, or incorporated in, the M&E being investigated. If no historical information is available, information on the current status of the M&E can be determined using preliminary surveys (i.e., scoping, characterization, remedial action support) prior to designing a disposition survey.

The recommendations in this supplement may be applied to a broad range of regulations, including dose-, risk-, or radionuclide concentration-based regulations. The translation of a regulatory dose- or risk-based limit to a corresponding concentration level is not addressed in MARSAME. The terms dose, risk, and dose- or risk-based regulation are used throughout the supplement, but these terms are not intended to limit the applicability of this supplement. MARSAME can be applied to activity concentrations (e.g., Bq/m^2) without associated dose or risk values. MARSAME does not address the regulatory status of the M&E (e.g., NRC exempted or excluded materials).

MARSAME uses the word “should” as a recommendation. This is not to be interpreted as a requirement. The user need not assume that every recommendation in this supplement will be taken literally and applied to every project. Rather, it is expected the survey documentation will address how the recommendations will be applied on a project-specific basis.

1.2 Understanding Key MARSAME Terminology

In order to understand the information in MARSAME, the user should first become familiar with the scope of this supplement, the terminology, and the concepts in this document. As a supplement to MARSSIM, MARSAME uses terms generally consistent with MARSSIM. Some additional terms were developed for MARSAME, while other commonly used terms were adopted from other sources. This section explains some of the terms used in this supplement. The terms *impacted*, *non-impacted,* and *graded approach* are defined in MARSSIM. These terms are used consistently in MARSSIM and MARSAME. Unlike MARSSIM, which applies to land, structures, or buildings, MARSAME applies to M&E. The action taken may initiate, maintain, remove, or transfer radiological controls associated with the M&E. The decision to take action may be largely based on the results of a radiological survey designed to evaluate the disposition of the M&E, either through release or interdiction. Therefore, the terms *release criterion*, *derived concentration guideline level* (DCGL), and *final status survey* used in MARSSIM are replaced by the more generic terms *disposition criterion*, *action level,* and *disposition survey,* respectively, in MARSAME.

Disposition is the future use, fate, or final location for something (e.g., recycle, reuse, disposal). Disposition options range from release to interdiction:

- *Release* is a reduction in the level of radiological control, or a transfer of control to another party. Release includes clearance. Examples of release (other than clearance) include recycle, reuse, disposal as waste, or transfer of control of radioactive M&E from one authorized user to another.

- *Interdiction* is an increase in the level of radiological control or a decision not to accept control from another party. Examples of interdiction include identification of radioactive material that results in the initiation of radiological controls or identification of unauthorized movement of radioactive material.

Categorization is the act of determining whether M&E are impacted or non-impacted. This is a departure from MARSSIM where this decision was referred to as classification. This change was made to emphasize the difference between the decision of whether a survey is needed (i.e., impacted or non-impacted) and the determination of the appropriate level of survey effort (i.e., classification).

Classification is the act or result of separating impacted M&E or survey units into one of three designated classes: Class 1, Class 2, or Class 3. Classification is the process of determining the appropriate level of survey effort based on estimates of activity levels and comparison to action levels, where the activity estimates are provided by historical information, process knowledge, and preliminary surveys.

Measurable radioactivity is radioactivity that can be quantified using known or predicted relationships developed from historical information, process knowledge or preliminary measurements as long as the relationships are developed, verified, and validated as specified in the DQOs and measurement quality objectives (MQOs). Measurability is of primary importance in MARSAME.

Surficial radioactive material is radioactive material distributed on any of the surfaces of a solid object. Surficial radioactive material may be *removable* (by non-destructive means such as casual contact, wiping, brushing, or washing) or *fixed*. Surfaces may either be accessible or difficult-to-measure. Changes to the surface (e.g., paint, dirt, oxidation) may affect the measurability and the physical condition of surficial radioactive material.

Survey unit for M&E is the specific lot, amount, or piece of M&E on which measurements are made to support a disposition decision concerning the same specific lot, amount, or piece of M&E. The survey unit defines the spatial boundaries for the disposition decision and a separate decision is made for each survey unit, similar to MARSSIM. The survey unit boundaries also define the population for the parameter of interest.

Volumetric radioactive material is radioactive material that is distributed throughout or within the material or equipment being measured, as opposed to a surficial distribution. Volumetric radioactive material may be homogeneously (e.g., uniformly activated metal) or heterogeneously (e.g., activated reinforced concrete) distributed throughout the M&E. Volumetric radioactive material may be distributed throughout the M&E being measured or distributed in layers. Layers of volumetric radioactive material may start at the surface (e.g., porous surfaces penetrated by radioactive material) or under a layer of other material (e.g., activated rebar inside a concrete wall). By definition all radioactive liquids and gases in containers and all bulk quantities of radioactive material when measured as a whole are volumetric radioactive material.

The concept of whether radioactivity is measurable is the major factor in demonstrating compliance with an action level. MARSAME does not provide an exact definition for the transition between surficial and volumetric radioactive material. Rather, the assumptions used to quantify the radioactivity need to be clearly defined and identified so they can be compared to the DQOs and MQOs. Individual action levels may specify applicability to surficial or volumetric radioactivity. In these cases, the definition of surficial and volumetric radioactivity should be specified as part of the definition of the action level.[1]

Accessible area is an area that can be easily reached or obtained. In many cases an area must be physically accessible to perform a measurement. However, radioactivity may be measurable even if M&E are not physically accessible (e.g., energetic gamma rays may be quantified even after passing through a layer of shielding).

Difficult-to-measure radioactivity is radioactivity that is not measurable until the M&E to be surveyed is prepared. Preparation of M&E may be relatively simple (e.g., cleaning) or more complicated (e.g., disassembly or complete destruction). Given sufficient resources, all radioactivity can be made measurable; however, it is recognized that increased survey costs can outweigh the benefit of some dispositions.

Initial assessment (IA) is an investigation to collect existing information describing M&E and is similar to the Historical Site Assessment (HSA) described in MARSSIM. The IA provides initial categorization of M&E as impacted or non-impacted. In addition to the HSA activities described in MARSSIM, the IA may lead to grouping or segregating M&E with similar characteristics as well as designing and implementing preliminary surveys. The IA also identifies the expected disposition of the M&E (e.g., clearance, radiological control, recycle, reuse, disposal). The results of the IA provide most, if not all, information needed to design a disposition survey for impacted M&E. A graded approach is used to determine the level of effort applied during the IA.

Sentinel measurement is a biased measurement performed at a key location to provide information specific to the objectives of the IA (see Section 2.2.4). Sentinel measurements cannot be used as the only source of information to support a decision that M&E are non-impacted. The objective of performing sentinel measurements as part of the IA is to gather additional information to support a decision regarding further action, verify assumptions based on process knowledge, provide additional support to a finding of impacted or non-impacted for M&E, and to distinguish illicit or inadvertent transport of radioactive materials from items in general commerce that are inherently radioactive (e.g., fertilizers, phosphates, sand-blasting grit).

1.3 Use of MARSAME

MARSAME provides technical information describing a framework for planning, implementing, and assessing radiological surveys of M&E. MARSAME does not establish or supersede any regulatory or license requirements. Federal and State regulatory agencies may have requirements or guidance that differs from what is presented in MARSAME and may be implemented as

[1] This idea is consistent with the definition of a surface soil sample provided in the MARSSIM Glossary. A surface soil sample is a sample that reflects the modeling assumptions used to develop the DCGL for surface soil activity. The example in MARSSIM references 40 CFR 192, which defines surface soil as the first 15 cm of soil.

appropriate. Consequently, persons planning, implementing, and assessing disposition surveys should also obtain appropriate regulatory approval for the procedures that are in use to maintain regulatory compliance.

Potential users of this supplement are Federal, State, and local government officials having authority for control of radioactive M&E, their contractors, and other parties such as organizations with licensed authority to possess and use radioactive materials. This supplement to MARSSIM is intended for a technical audience having knowledge of radiation health physics and an understanding of statistics as well as experience with the practical applications of radiation protection. Understanding and applying the recommendations in this supplement requires knowledge of instrumentation and measurement methodologies as well as expertise in planning, approving, and implementing radiological surveys. Certain situations and projects may require consultation with more experienced or specialized personnel (e.g., a statistician).

MARSAME users with less professional experience than described above should still be able to apply the majority of guidance found in this supplement although obtaining technical support is recommended. The wide range of topics and subjects covered by MARSAME emphasizes the need for a well rounded planning team as described in the first step of the DQO process. While it may be difficult to identify a single person with all the required technical experience to design an appropriate survey, it is easier to assemble a small group of experts with the required range of knowledge. Consultation with the responsible regulatory agency is critical for the success of all disposition surveys, and even more so for MARSAME users with less professional experience. In addition, MARSAME provides information in Appendix B, Appendix C, and Appendix D that may be useful to users with less professional experience.

MARSAME recommends that a graded approach be applied to the disposition of M&E. Non-impacted M&E are removed from further consideration early in the process through categorization. Impacted M&E are classified based on the level of residual radioactivity so that a higher level of scrutiny can be applied to M&E with the highest potential for residual radioactivity. Finally, MARSAME includes practical considerations such as inherent value of the M&E and handling the M&E when evaluating options for disposition. The combination of these considerations results in a graded approach where an appropriate level of survey effort is applied to M&E to minimize the impacts of any decision errors.

1.4 Overview of MARSAME

The data life cycle is the foundation for the design, implementation, and assessment of surveys for disposition of M&E in this supplement. However, before commencing survey planning the user must select an appropriate disposition option. Multiple disposition options may exist. Consider all of the various disposition options and develop the most appropriate option for a given situation. Survey designs may then be planned using the DQO process, which is often iterative. The DQO process iterations may take place at different times during the disposition process, for example during the IA as well as during the disposition survey. The different survey designs are compared and the most resource-effective design that meets the survey objectives is selected for implementation. Following implementation of the selected survey design, the results are evaluated using data quality assessment (DQA). A technically defensible decision regarding disposition of the M&E can then be made.

Whenever practical, MARSAME recommends designing disposition surveys where one hundred percent of the M&E are measurable. This means that all radioactivity associated with the M&E has been measured and quantified (e.g., 100% scan with conventional instruments, measurement with a box counter, or measurement using in situ gamma spectroscopy), a known or accepted relationship was used to estimate concentrations for difficult to measure radionuclides using surrogate measurements,[2] or that a known or accepted relationship allows quantification of radioactivity in areas that were not measured. MARSAME employs the use of a graded approach to determine if a 100% measurable survey is practical and to ensure that a sensible, commensurate balance is achieved between resource expenditures and risk reduction.

MARSAME uses the data life cycle to design disposition surveys. The data life cycle is described in MARSSIM Section 2.3, and consists of four phases:

- Planning phase (MARSAME Chapters 2, 3, and 4; MARSSIM Chapters 3, 4, and 5),
- Implementation phase (MARSAME Chapter 5; MARSSIM Chapters 6 and 7),
- Assessment phase (MARSAME Chapter 6; MARSSIM Chapter 8), and
- Decision-making phase (MARSAME Chapter 6; MARSSIM Chapter 8).

A brief description of each of the phases and how they apply to the disposition survey design process is provided in the following sections. Table 1.1 provides a simplified overview of the principal steps in designing a disposition survey and illustrates how the data life cycle can be used in an iterative fashion within the survey process. Figure 1.1 illustrates how the data life cycle is applied to disposition surveys.

Table 1.1 The Data Life Cycle Used to Support Disposition Survey Design

Disposition Survey Design Process	**Data Life Cycle**		**MARSAME Processes**
Categorization	Categorization Data Life Cycle	Plan Implement Assess Decide	Provides information on collecting and assessing existing data (Section 2.2)
Preliminary Surveys	Preliminary Survey Data Life Cycle	Plan Implement Assess Decide	Discusses the purpose (i.e., filling data gaps) and general approach to performing preliminary surveys (Section 2.3)
Disposition Survey	Disposition Survey Data Life Cycle	Plan Implement Assess Decide	Provides detailed information for planning (Chapters 3 and 4), implementing (Chapter 5), and assessing (Chapter 6) disposition surveys

[2] The MARSSIM term “surrogate measurement” as used here is consistent with the MARLAP term “alternate radionuclide.”

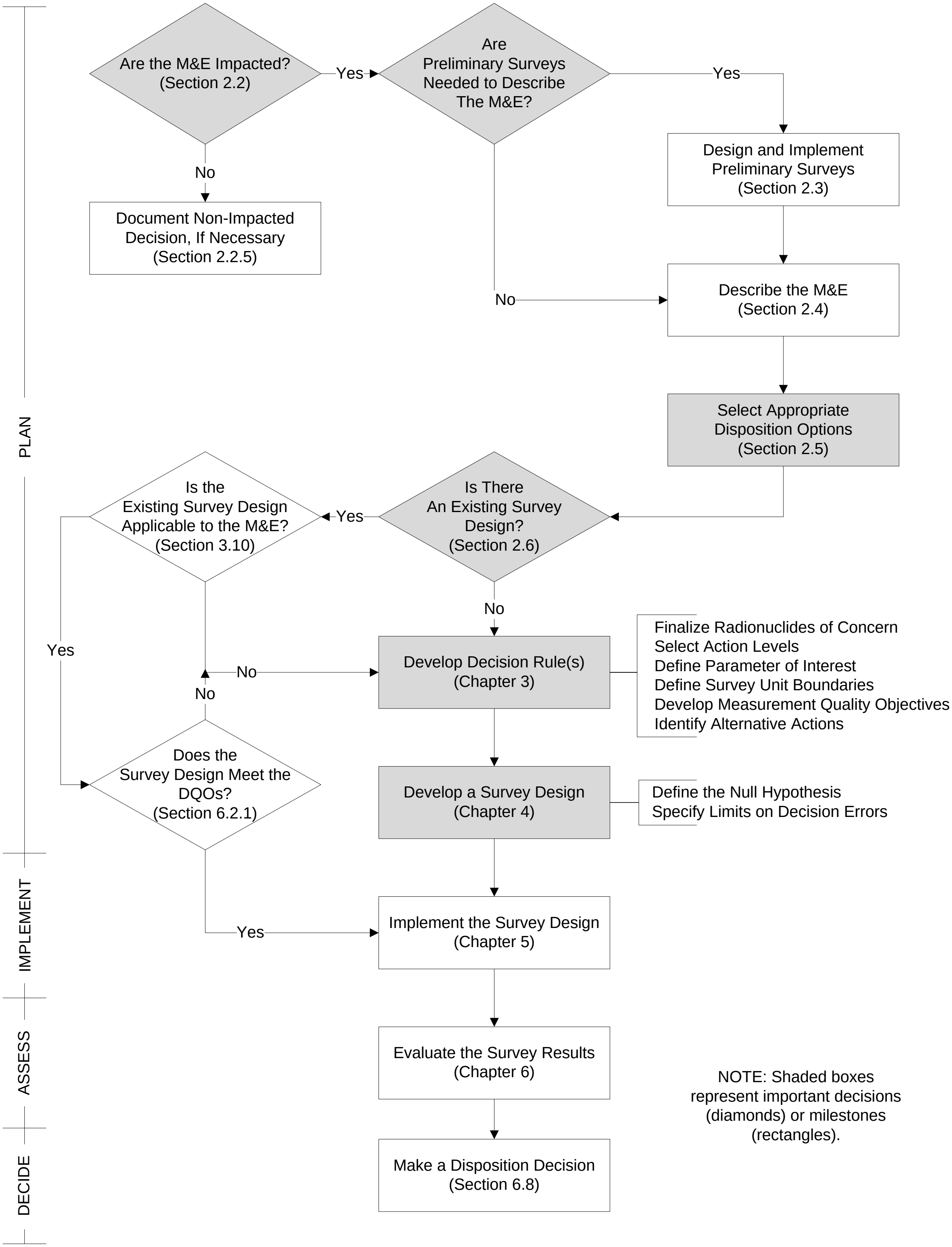

Figure 1.1 The Data Life Cycle Applied to Disposition Surveys

1.4.1 Planning Phase

The planning phase is where the survey design is developed and documented using the DQO process. The survey design documents the decision rule as well as the number, type, and location of measurements required to support the disposition decision. Soliciting input from regulatory agencies early in the planning phase helps ensure the disposition survey results will meet regulatory needs.

MARSAME processes begin with the historical evaluation of the M&E being investigated. This IA usually combines a review of process knowledge and historical records with a visual inspection of the M&E. The results of the IA are used to develop a conceptual model describing the physical characteristics of the M&E and providing information on the radioactivity potentially associated with the M&E. The physical description of the M&E should include information on the size, shape, complexity (e.g., can it be broken down or combined with other M&E), accessibility (e.g., can the surveyor physically access areas of concern to perform measurements), and inherent value (i.e., resources associated with reuse, recycle, repair, remediation, replacement, and disposal). Information on radioactivity should include the radionuclides of potential concern, the expected levels of radioactivity, the distribution of radioactivity (e.g., uniform or not), and the location of the radioactivity (i.e., surface or volume).

The IA may also include data collection in the form of sentinel measurements. The results of sentinel measurements can be used as the basis to reject assumptions based on process knowledge. However, sentinel measurements alone cannot be used to justify the categorization of M&E as non-impacted (see Section 2.2.4 for information on sentinel measurements).

There are two decisions associated with the IA. The first decision, called categorization, is whether or not the M&E are impacted. Non-impacted M&E do not require additional investigation, but may require documentation of the justification for the non-impacted decision. The second decision is to select an appropriate disposition option for impacted M&E at the end of the IA to provide direction for designing a disposition survey. Additional information may be required before a disposition survey can be designed. Preliminary surveys (e.g., scoping, characterization, and remedial action support surveys) may be performed as part of the IA to collect this additional information.

For single event surveys, the IA should focus on collecting the information necessary to develop a technically defensible disposition survey design. Information necessary to design a disposition survey includes a description of the M&E and the radioactivity potentially associated with the M&E. The results of the IA are carried forward and used to develop the survey design, which is usually documented in a project-specific work plan.

For routine process surveys, the IA should lead to an existing survey design from a standard operating procedure (SOP), if applicable, or develop a new survey design for documentation in an SOP. The SOP should clearly state the assumptions used to develop the survey design, along with a description of the M&E and radioactivity covered by the SOP. The selection process is based on evaluating the M&E to determine if the survey design in a specific SOP is applicable. Documentation of individual survey results may not be required as long as there are records showing that the SOP was approved, the instruments were working properly, and the personnel performing the survey were properly trained. Development of SOPs is usually accomplished using the same processes as those used to develop single event surveys. There may be regulatory or site-specific guidance that specifies documentation requirements for SOPs. Information on developing SOPs can be found in EPA QA/G-6 (EPA 2001).

Following the IA, it is necessary to develop a decision rule for the disposition of M&E being investigated. The decision rule is an "if...then..." statement consisting of three parts:

- Action level(s),
- Parameter of interest, and
- Alternative actions.

An example of a decision rule might be "If the average surficial activity concentration is less than a level specified by the regulator, then the M&E can be cleared, otherwise the M&E are not cleared." The parameter of interest is closely related to the description of the M&E, the description of the radioactivity, and the survey unit boundaries. The action level is influenced by the selection of a disposition option. The selected disposition option defines two alternative actions. A decision rule should be developed for each decision to be made concerning the M&E. For example, if the action level is stated in terms of total activity, generally only one decision rule is required. If, on the other hand, the action level provides limits for fixed, removable, and maximum levels of radioactivity, e.g., DOE Order 5400.5, Figure IV-1 (DOE 1993), then a decision rule is required to evaluate each action level. The measurement performance requirements, or MQOs, are also evaluated when developing a decision rule to ensure that an acceptable measurement technique is available to support the proposed survey design.

Once the decision rule(s) have been established, a survey design is developed. The survey design specifies the number and quality of measurements required to support a disposition decision recorded in the decision rule. MARSAME recommends applying a graded approach to designing disposition surveys (Section 4.4). The survey design, definitions of decision errors, and burden of proof are determined by the selection of a null hypothesis (Section 4.2).

The survey design should be documented in a quality document (e.g., QA Survey Plan, SOP) that has been reviewed and accepted by the appropriate authority (e.g., technical expert, management, or regulator). Survey designs that are often repeated may be documented in SOPs along with supporting records on instrument performance and personnel training. Other types of disposition surveys are usually documented in a project-specific work plan and survey results are presented in a disposition survey report (Sections 2.5 and 4.5). If the selected survey design is not technically or economically practical, the planning team can investigate additional disposition options if necessary (Sections 2.4 and 4.4).

1.4.2 Implementation Phase

To ensure flexibility and encourage the use of optimal measurement techniques for a specific project, MARSAME does not provide detailed information on specific implementation techniques. However, detailed descriptions of several measurement techniques are provided

(Chapter 5 and Appendix D). These descriptions serve as a template for information required to evaluate different measurement techniques. It is important to remember that the survey design is usually linked to a specific option for disposition of the M&E (Chapters 3 and 4).

During implementation, the descriptions of measurement techniques are compared to the MQOs defined during survey planning. A measurement method (i.e., combination of a measurement technique with an instrument; see Section 5.9) is selected based on its ability to meet the MQOs. The number and type of measurements specified in the documented survey design are performed at the locations specified in the survey design. If a measurement method is specified in the survey design, that method should generally be used during implementation. If the specified measurement method cannot be performed (e.g., the instrument is unavailable or the measurement method does not meet the MQOs), another measurement method should be selected based on the MQOs. The selection of the replacement measurement method should be documented in the survey design and survey report.

An action level may be established for implementing disposition surveys to support disposition decisions about individual objects or measurement locations. If this action level is in the same units as measurements performed in the field, then the surveyor can make final disposition decisions by directly comparing the measurement results to the action level as the measurements are performed. This may allow the surveyor to perform remediation as required and implement a “clean as you go” component to the survey design (Section 6.9). Clean as you go surveys may reduce the amount of M&E requiring additional consideration following completion of the disposition survey. This clean as you go approach to surveys is only applicable for Class 1 surveys (i.e., radionuclide concentrations or radiation levels exceed the action level and 100% of M&E are measured) where there is high confidence in the quality and accuracy of detection decisions.

Quality control (QC) data are collected and analyzed during implementation to provide an estimate of the uncertainty associated with the survey results. QC measurements are technical activities performed to measure the attributes and performance of a survey. A well-designed QC program increases efficiency and provides for early detection of problems. This can save time and money by averting rework and enables the user to make decisions more expeditiously (EPA 2002c).

1.4.3 Assessment Phase

The assessment phase begins with verification and validation of the survey results. Data verification is used to ensure the requirements documented in the survey design were implemented as prescribed. Data validation ensures the results of the data collection activities support the objectives of the survey (i.e., DQOs), or permit a determination that these objectives should be modified (MARSSIM Section 9.3 and MARSSIM Appendix N).

DQA determines if the collected data are of the right type, quality, and quantity to support their intended use. DQA helps complete the data life cycle by providing the assessment needed to determine that the planning objectives are achieved. DQA is described in detail in EPA QA/G-9R (EPA 2006b), MARSSIM Section 8.2, and MARSSIM Appendix E.

The preliminary data review is performed to learn about the structure of the data (e.g., identifying patterns, relationships, or potential anomalies). Graphical techniques are used to help visualize the data. Calculation of basic statistical quantities is used to help describe the distribution of data.

The survey data are evaluated using a statistical test. A test statistic is calculated and compared to a critical value. The critical value divides the potential values of the test statistic into two regions. The critical region includes values for the test statistic where the null hypothesis is rejected. The null hypothesis is not rejected for values of the test statistic outside the critical region. Keep in mind that a statistical test could be as simple as comparing survey results directly to the critical value to ensure no radiation is detected, or may involve using a more complex statistical evaluation such as the Wilcoxon Rank Sum (WRS) test.

In some cases the assessment phase may be performed during survey implementation. For example, the "clean as you go" approach described in Section 6.9 requires that field data be assessed and a decision made concerning the M&E being measured. The M&E are "cleaned," or remediated, as necessary and another disposition survey performed.

1.4.4 Decision-Making Phase

Following the assessment phase, a decision is made regarding the disposition of the M&E. The decision rule defines the final decision. The statistical test or data comparison determines whether the parameter of interest exceeds the action level. Based on the outcome, a decision can be made regarding the alternative actions. If multiple decision rules are defined for a single disposition survey (e.g., a MARSSIM-type survey where the average activity is evaluated using a statistical test and small areas of elevated activity are evaluated using the elevated measurement comparison) any one decision that the action level has been exceeded should result in additional investigation.

In some cases the decision making phase may be performed during survey implementation. For example, the "clean as you go" approach described in Section 6.9 requires that field data be assessed and a decision made concerning the M&E being measured. The M&E are "cleaned," or remediated, as necessary and another disposition survey is performed.

1.5 Organization of MARSAME

The planning, implementation, and assessment of disposition surveys in MARSAME are based on the data life cycle. Each chapter in MARSAME provides information for specific steps in the process. The planning phase is discussed in Chapters 2, 3, and 4. The implementation phase is discussed in Chapter 5, and Chapter 6 discusses the assessment phase and decision-making phase.

Chapter 2 focuses on the IA. Information is provided on categorizing whether the M&E are impacted or non-impacted using existing data and sentinel measurements in Section 2.2. Information on designing and implementing preliminary surveys to provide the information needed to design a disposition survey is provided in Section 2.3. Discussions on describing the

M&E being surveyed are provided in Section 2.4. The selection of a disposition option and development of a conceptual model are discussed in Section 2.5. Information pertaining to documenting the results of the IA is provided in Section 2.6.

Chapter 3 provides information on developing a decision rule and discusses other inputs needed to design a disposition survey. Section 3.2 addresses selecting the radionuclides or radiations of concern which must be established before forming a decision rule. There are three parts to a decision rule–

- Action level(s), discussed in Section 3.3,
- Parameter of interest, discussed in Section 3.4, and
- Alternative actions, discussed in Section 3.5.

Section 3.7 brings these three components together to develop decision rule(s) that are used to design the disposition survey in Chapter 4. Survey units are discussed in Section 3.6, and inputs for selecting measurement methods are presented in Section 3.8. Section 3.9 identifies reference materials that can be used to estimate background radionuclide concentrations or radiation levels. The process for evaluating an existing survey design is described in Section 3.10.

Chapter 4 completes the planning phase with the development of a survey design. This chapter discusses the selection of a null hypothesis and setting tolerable limits on decision errors (Section 4.2), determines the level of survey effort for the disposition survey (Section 4.3), and determines the type, number, and location of measurements to support a disposition decision (Section 4.4). Information pertaining to disposition survey design documentation is provided in Section 4.5. The processes in Chapter 4 result in a documented survey design.

The implementation processes in Chapter 5 focus on selection of an appropriate measurement technique. Recommendations are provided on issues related to health and safety that may impact the implementation of disposition surveys (Section 5.2). Chapter 5 also provides information on process control and handling of potentially radioactive M&E (Section 5.3). The use of segregation to help improve the efficiency of measurements and detectability of radioactivity, and as a tool to limit the uncertainty is described in Section 5.4. Sections 5.5 through 5.8 discuss the establishment of measurement uncertainty, measurement detectability, and measurement quantifiability as MQOs to validate the measurement method’s ability to meet the established performance objectives. Information is provided on several measurement techniques (Section 5.9) that can be used for comparison to the MQOs developed in Chapter 3. These descriptions can also be used during the planning phase to specify a measurement technique in the survey design. Recommendations related to QC are also provided to ensure that survey instruments are functioning properly, and the data meet defined performance limits specified during planning (Section 5.10). Information related to collecting and documenting survey data is discussed in Section 5.11.

Chapter 6 provides methods for the assessment and decision-making phases. Recommendations are provided for performing the preliminary data review, calculating statistical quantities, and preparing graphic representations that will assist the user in exploring the data (Section 6.2). Disposition decisions about individual items may be based on individual measurement results by comparing data to the upper bound of the gray region (Section 6.3). Information is also provided for calculating the upper confidence limit (Section 6.4). Details on performing recommended statistical tests are also included (Sections 6.5 through 6.7). This chapter also describes how to make a disposition decision based on the survey results (Section 6.8), what to do if the selected disposition option is not accepted (Section 6.9), and the documentation to support the decision (Section 6.10).

Chapter 7 discusses the general concepts of statistical survey design and hypothesis testing. Detailed discussions and calculations of MQOs, measurement uncertainty, minimum detectable concentrations (MDCs), and minimum quantifiable concentrations (MQCs) are provided in this chapter. Details and examples of each topic are provided. A detailed example of a scan MDC calculation is provided that is used to support the illustrative examples in Chapter 8.

Chapter 8 provides detailed illustrative examples implementing specific concepts found throughout MARSAME. The illustrative examples cover a range of material, equipment, radionuclides, and disposition options. Sections of these illustrative examples are used to illustrate specific concepts throughout the supplement.

MARSAME contains several appendices to provide additional information on specific topics. Appendix A provides copies of statistical tables needed to implement the information in MARSAME. Appendix B lists sources of environmental radiation such as natural background and fallout. A list of potential radionuclides grouped by industry or type of facility is provided in Appendix C. Appendix D provides detailed information on specific measurement systems unique to disposition surveys. Appendix E lists and describes some of the potential sources of action levels applicable to decisions regarding disposition of M&E.

1.6 Similarities and Differences Between MARSSIM and MARSAME

During the 1990s, there was a concerted effort to improve the planning, implementation, evaluation, and documentation of building surface and surface soil final radiological surveys for demonstrating compliance with standards. This effort included the preparation of NUREG-1505 (NRC 1998a) and NUREG-1507 (NRC 1998b) by the NRC and culminated in 1997 with the issuance of MARSSIM (MARSSIM 2002). MARSSIM was a joint effort by DOD, DOE, EPA, and NRC to develop a multi-agency approach for planning, performing, and assessing the ability of surveys to meet dose- or risk-based standards while at the same time encouraging effective use of resources. MARSSIM provided recommendations for developing appropriate final status survey designs using the DQO process to ensure survey results were of sufficient quality and quantity to support a final decision. MARSSIM (MARSSIM 2002), NUREG-1505 (NRC 1998a), and NUREG-1507 (NRC 1998b) replaced the previous approach for such surveys contained in NUREG/CR-5849 (NRC 1992).

This MARSAME supplement expands the scope of MARSSIM methods and processes to provide technical information supporting the disposition decision for M&E, specifically the design and implementation of disposition surveys, to ensure the disposition decision is technically defensible and optimized for efficiency. MARSSIM addressed the disposition of real property (e.g., buildings and land) where the only disposition options were unrestricted release, restricted release, or maintaining radiological controls. MARSAME addresses the disposition of non-real property (e.g., M&E) and includes additional options for future use including recycle or disposal as radioactive waste (see Section 2.5). Increasing radiological controls and interdiction are also included as potential disposition options. While several, or all, disposition alternatives may be acceptable for a specific project, optimizing the disposition survey design based on the selected disposition alternative is described in MARSAME.

MARSAME as a supplement to MARSSIM expands the scope of technically sound measurement processes and methods to include M&E. Table 1.2 summarizes the major similarities between MARSSIM and MARSAME, which result from application of a graded approach to support a technically defensible decision regarding disposition. Table 1.3 summarizes the major differences between MARSSIM and MARSAME, which result from the change from real to non-real property.

Table 1.2 Similarities Between MARSSIM and MARSAME

Parameter	MARSSIM	MARSAME
Graded Approach	Used to place greater survey effort on areas that have, or had, the highest potential for residual radioactivity.	Used to place greater survey effort on M&E that have, or had, the highest potential for residual radioactivity.
Data Quality Objectives (DQO) Process	Used to design technically defensible surveys to support decisions on disposition of real property.	Used to design technically defensible surveys to support decisions on disposition of non-real property (e.g., M&E).
Data Quality Assessment (DQA)	Used to evaluate survey results and support a decision of whether to release real property.	Used to evaluate survey results and support a disposition decision for non-real property.
Process Knowledge	Used during the Historical Site Assessment to support the determination of whether an area is impacted and provide information for designing subsequent surveys.	Used during the Initial Assessment to support the determination of whether M&E are impacted and provide information for designing subsequent surveys.
Classification	Determines the level of survey effort based on the potential amount of residual radioactivity present.	Determines the level of survey effort based on the potential amount of residual radioactivity present.
Flexibility	MARSSIM allows and encourages flexibility in the design and implementation of final status surveys for application to diverse site conditions.	MARSAME allows and encourages flexibility in the design and implementation of disposition surveys for application to diverse M&E.
Statistics	Used to develop a technically defensible survey design.	Used to develop a technically defensible survey design.
Scale of Decision Making	A separate release decision is made for every survey unit.	A separate release decision is made for every survey unit.
Inherent Radioactivity	Inherent radioactivity is site-specific and generally cannot be separated from ambient radiation.	Inherent radioactivity is specific to the M&E being investigated. Segregation of M&E based on inherent radioactivity can be used to reduce measurement variability.

Table 1.3 Differences Between MARSSIM and MARSAME

Parameter	MARSSIM	MARSAME
Scope	Surface soil and building surface surveys (i.e., real property).	Materials and equipment (i.e., non-real property).
Disposition Options	Restricted or unrestricted release, or fail to release.	Release survey (maintain, remove, or transfer radiological control; clearance for reuse, recycling, or disposal), or Interdiction survey (increase in the level of radiological control or a decision not to accept control from another party).
Categorization	Included as part of classification in MARSSIM.	Separates the decision to survey from determining level of survey effort.
Application of the Graded Approach	Classification and survey unit size result in varying levels of survey effort.	Multiple disposition options result in varying levels of survey effort.
Sentinel Measurements	Not described in MARSSIM.	Allows use of sentinel measurements during IA to check validity of certain process knowledge assumptions.
Documentation of Survey Designs	Assumes project-specific survey designs will be developed for individual sites.	In addition to project-specific survey design, allows SOPs for categories of M&E to provide standard approach to disposition surveys.
Preliminary Surveys	Scoping and characterization surveys regularly used to obtain information needed to design a final status survey.	Scoping and characterization surveys rarely used to obtain information needed to design a disposition survey. Historical information obtained during the IA is generally sufficient to design a disposition survey. If not, preliminary surveys may be used to provide the necessary information.
Ambient Radiation	Ambient radiation is site-specific and generally cannot be separated from inherent radioactivity.	Ambient radiation is selected based on location where disposition surveys are performed, and can be separated from inherent radioactivity.
Interdiction	Not addressed in MARSSIM.	Surveys may be performed to identify radioactive material resulting in an increase in the level of radiological control or deciding not to accept control from another party. For example, identifying radioactive materials and initiating radiological controls, or identifying unauthorized movement of radioactive material.

Table 1.3 Differences Between MARSSIM and MARSAME (Continued)

Parameter	MARSSIM	MARSAME
Null Hypothesis	MARSSIM recommends using the null hypothesis: “The activity in the survey unit exceeds the action level (Scenario A).” MARSSIM allows using the null hypothesis: “The activity in the survey unit is indistinguishable from background (Scenario B) with information from NUREG-1505 (NRC 1998a).”	User selects the appropriate null hypothesis: “The activity in the survey unit exceeds the action level (Scenario A).” or “The activity in the survey unit is indistinguishable from background (Scenario B).”
Scan-Only Surveys	Not addressed in MARSSIM	M&E may be dispositioned based on the results of scan-only surveys provided the scan measurements meet the MQOs for the survey.
In Situ Surveys	Not addressed in MARSSIM	M&E may be dispositioned based on the results of in situ surveys provided the in situ measurements meet the MQOs for the survey.