UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C. 20460

OFFICE OF THE ADMINISTRATOR
SCIENCE ADVISORY BOARD

- - - Date to be Inserted - - -

EPA-SAB-08-XXX

The Honorable Stephen L. Johnson
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, DC 20460

Subject: Re Review of a Multi-Agency Work Group Draft Document entitled ***"Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual (MARSAME),"*** Draft Report for Comment, December 2006

Dear Administrator Johnson:

The Radiation Advisory Committee (RAC) Multi-Agency Radiation Survey and Assessment of Materials and Epuipment (MARSAME) Review Panel of the Science Advisory Board has completed its review of the Multi-Agency Work Group draft document entitled ***"Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual (MARSAME),"*** Draft Report for Comment, December 2006.

RESERVED FOR FUTURE DEVELOPMENT

NOTICE

This report has been written as part of the activities of the EPA Science Advisory Board (SAB), a public advisory group providing extramural scientific information and advice to the Administrator and other officials of the Environmental Protection Agency. The SAB is structured to provide balanced, expert assessment of scientific matters related to problems facing the Agency. This report has not been reviewed for approval by the Agency and, hence, the contents of this advisory do not necessarily represent the views and policies of the Environmental Protection Agency, nor of other agencies in the Executive Branch of the Federal government, nor does mention of trade names of commercial products constitute a recommendation for use. Reports and advisories of the SAB are posted on the EPA website at http://www.epa.gov/sab.

U.S. Environmental Protection Agency
Science Advisory Board
Radiation Advisory Committee (RAC)
Multi-Agency Radiation Survey and Assessment of Materials and Equipment (MARSAME) Manual Review Panel

CHAIR:
Dr. Bernd Kahn, Professor Emeritus, School of Nuclear Engineering and Health Physics, and Director, Environmental Radiation Center, Georgia Institute of Technology, Atlanta, GA

PAST CHAIR:
Dr. Jill Lipoti, Director, Division of Environmental Safety and Health, New Jersey Department of Environmental Protection, Trenton, NJ

RAC MEMBERS:
Dr. Thomas B. Borak, Professor, Department of Environmental and Radiological Health Sciences, Colorado State University, Fort Collins, CO

Dr. Antone L. Brooks, Professor, Radiation Toxicology, Washington State University Tri-Cities, Richland, WA

Dr. Faith G. Davis, Senior Associate Dean and Director of Graduate Studies, Professor of Epidemiology, Division of Epidemiology and Biostatistics, School of Public Health, University of Illinois at Chicago, Chicago, IL

Dr. Brian Dodd, Consultant, Las Vegas, NV

Dr. Shirley A. Fry, M.B., B. Ch., MPH, Consultant, Indianapolis, IN

Dr. William C. Griffith, Associate Director, Institute for Risk Analysis and Risk Communication, Department of Environmental and Occupational Health Sciences, University of Washington, Seattle, WA

Dr. Jonathan M. Links, Professor, Department of Environmental Health Sciences, Bloomberg School of Public Health, Johns Hopkins University, Baltimore, MD

Mr. Bruce A. Napier, Staff Scientist, Radiological Science & Engineering Group, Pacific Northwest National Laboratory, Richland, WA

Dr. Daniel O. Stram, Professor, Department of Preventive Medicine, Division of Biostatistics and Genetic Epidemiology, Keck School of Medicine, University of Southern California, Los Angeles, CA
Dr. Richard J. Vetter, Head, Radiation Safety Program, Mayo Clinic, Rochester, MN

CONSULTANTS:
Mr. Bruce Church, President, BWC Enterprises, Inc., Hurricane, UT

Mr. Kenneth Duvall, Environmental Scientist/Consultant, Washington, D.C.

Dr. Janet A. Johnson, Consultant, Carbondale, CO 81623

Dr. Paul J. Merges, President, Environment & Radiation Specialists, Inc., Loudonville, N.Y.

SCIENCE ADVISORY BOARD STAFF
Dr. K. Jack Kooyoomjian, Designated Federal Officer, 1200 Pennsylvania Avenue, NW, Washington, DC, 20460-0001, Phone: 202-343-9984, Fax: 202-233-0643, or 0645 (kooyoomjian.jack@epa.gov) Messenger/Physical Delivery Address: 1025 F Street, NW, Room 3606, Mail Code 1400F

U.S. Environmental Protection Agency
Science Advisory Board
BOARD

Provide Roster here. DFO will get update of Charter Science Advisory Board roster and insert here.

SCIENCE ADVISORY BOARD STAFF

Mr. Thomas Miller, Washington, DC

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY

The Radiation Advisory Committee (RAC) of the Science Advisory Board (SAB) has completed its review of the Multi-Agency Work Group draft document entitled ***"Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual (MARSAME),"*** Draft Report for Comment, December 2006 (U.S. EPA. 2006; See also the MARSAME Hotlink at http://www.marsame.org). The Multi-Agency Radiation Survey and Assessment of Materials and Equipment (MARSAME) document presents a framework for planning, implementing, and assessing radiological surveys of material and equipment (M&E). MARSAME supplements the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM; See also the MARSSIM Hotlink at http://epa.gov/radiation/marssim/index.html), and refers to information provided in the Multi-Agency Radiological Laboratory Analytical Protocols manual (MARLAP; See also the MARLAP Hotlink at http://epa.gov/radiation/marlap/index.html). All of these were prepared by a work group that is a joint effort by staff members of multiple pertinent Federal agencies. The three documents, taken together, describe radiological survey programs in great detail and address recommendations to competent professionals and managers for performing such surveys. The surveys are designed to compare measurements to radionuclide concentrations specified in regulations or guides for accepting or rejecting a program or process. Vocabulary and techniques in MARSAME are carried forward from MARSSIM and MARLAP, with a few items added that are particularly applicable to M&E surveys.

The MARSAME document also pertains to surveying possibly radioactive M&E that may be in nature or in commerce when considered for acceptance or release. It presents a thorough grand overview of the various aspects of initial assessment, decision inputs, survey design, survey implementation, and assessment of results. In addition, some aspects, such as hypothesis testing and statistical aspects of measurement reliability are described in considerable detail. A number of illustrative examples are presented, and useful information is collected in appendices.

This review of the MARSAME document by an EPA-SAB Radiation Advisory Committee (RAC) Panel was requested by the EPA Office of Radiation and Indoor Air (ORIA). The review is based on reading the MARSAME Draft Report for Comment (December 2006), presentations by MARSAME work group members on October 29–31, 2007, and teleconferences among Panel members. The review responds to the set of charge questions posed by ORIA, but also refers to certain other technical items.

The Panel recognizes the magnitude of the effort by the work group and the value of its product; it notes that the Panel suggestions for changes address only a small fraction of this product. Most Panel recommendations can be summarized in the following broad categories:

- MARSAME guidance is suitable for experienced radiation protection and surveillance staff, but use by other interested readers, such as managers, will require that they receive special training;

- Appropriate advice and information should be added for use of (a) available regulations and technical guidance for the action limit (AL), (b) decontamination applied as part of the disposition plan, and (c) measurements to distinguish removable surface contamination and volumetric contamination from fixed surface contamination; and

- The specialized guidance for applying statistical tools should be separated from the otherwise pervasive non-quantitative guidance, both for the convenience of the general audience and for acceptance by specialists.

The above items are discussed within the context of the charge questions.

Because of the importance given by the work group to the mathematical support structure, a sub-group of the Panel has prepared a guide to placing portions of MARSAME devoted to matters such as survey design, the gray region, and hypothesis testing in a context that is easily accessible to persons generally familiar with statistical analysis. This guide is in the Appendix (See Appendix A) to this review.

2. INTRODUCTION

2.1 Background

The MARSAME document was designed to guide a professional through all aspects of radiological surveys of M&E prior to their intended receipt or discharge. It is written sufficiently broadly to pertain to all types of M&E. Cited as examples are metals, concrete, tools, trash, equipment, furniture, containers of material, and piping, among others. The presented alternative outcomes are release or interdiction, i.e., acceptance or rejection of M&E transfer.

The document was prepared by staff working together from the following Federal agencies: US EPA, US NRC, US DOE, and US DoD. It is part of a continuing effort that began with writing MARSSIM and continued with MARLAP. As a result, the methodology and associated vocabulary in MARSAME follow those of the preceding manuals, although a few aspects of MARSAME are distinct. Notably, MARSAME may be connected to MARSSIM as part of a site survey, or stand by itself in considering the transfer of M&E.

Surveys described in the MARSAME manual and its predecessors are based on the Data Quality Objectives (DQO) process to design the best survey with regard to disposition option, action level, and M&E description. The Data Life Cycle (DLC) supports DQO by carrying suitable information through the planning, implementation, assessment, and decision stages of the program. The data are collected, evaluated, and applied in terms of Measurement Quality Objectives (MQO) established with statistical concepts of data uncertainty and minimum quantifiable concentrations.

The MARSAME document is structured as follows, shown with the related charge question (CQ):

Acronyms and Abbreviations
Symbols, Nomenclature, and Notations
Conversion factors
Road Map (CQ 3)
Chapter 1, Introduction and overview (CQ 1)
Chapter 2, Initial assessment of M&E (CQ 1a)
Chapter 3, Identify inputs for the decision (CQ 1b)
Chapter 4, Survey design (CQ 1c)
Chapter 5, Implementation of disposition surveys (CG 2a)
Chapter 6, Assess the results of the disposition survey (CQ 2b)
Chapter 7, Case studies (CQ 1d and 2c)
7 Appendices (CQ 3)
References
Glossary

Responding to the charge questions was the primary purpose of the RAC Panel and is addressed first. The Panel also addressed some other topics, commented in detail on the MARSAME discussion of statistical aspects, and suggested corrections where needed.

2.2 Review Process and Acknowledgement

The U.S. EPA's Office of Radiation and Indoor Air (ORIA), on behalf of the Federal Agencies participating in the development of the MARSAME Manual, requested the U.S. SAB to provide advice on a draft Multi-Agency Work Group document entitled *"Multi-Agency Radiation Survey and Assessment of Materials and Equipment (MARSAME) Manual,"* December 2006. MARSAME is a supplement to the "Multi-Agency Radiation Survey and Site Investigation Manual" (MARSSIM, EPA 402-R-970-016, Rev. 1, August 2000 and June 2001 update). The SAB Staff Office announced this advisory activity and requested nominations for technical experts to augment the SAB's Radiation Advisory Committee (RAC) in the Federal Register (72 FR 11356; March 13, 2007). MARSAME was developed collaboratively by the Multi-Agency Work Group (60 FR 12555; March 7, 1995) and provides technical information on approaches for planning, conducting, evaluating, and documenting radiological disposition surveys to determine proper disposition of materials and equipment (M&E). The techniques, methodologies, and philosdophies that form the basis of this manual have been developed to be consistent with current Federal limitations, guidelines, and procedures.

The SAB RAC MARSAME Review Panel met in an initial public teleconference meeting on Tuesday, October 9, 2007 to introduce the subject and discuss the charge to the Panel, determine if the review and background materials provided are adequate to respond to the charge questions directed to the SAB's RAC MARSAME Review Panel, and agree on charge assignments for the Panelists. The purpose of the meeting of Monday, October 29 through Wednesday, October 31, 2007 was to receive presentations by the Multi-Agency Work Group staff, deliberate on the charge questions, and draft a report in response to the charge questions pertaining to the draft MARSAME Manual, dated December 2006. ……………(continue with Dec 21, 2007 and March 10, 2008 conference calls, etc. - - - KJK)………..

2.3 EPA Charge to the Panel

The EPA's Science Advisory Board (SAB) conducted the scientific peer reviews of the companion multi-agency documents MARSSIM (EPA-SAB-RAC-97-008, dated September 30, 1997) and MARLAP (EPA-SAB-RAC-03-009, dated June 6, 2003), and the Federal agencies participating in those peer reviews found the process used by the SAB to be extremely beneficial in assuring the accuracy and usability of the final manuals. Consequently, two consultations have taken place for MARSAME (EPA-SAB-RAC-CON-03-002, dated February 27, 2003, and EPA-SAB-RAC-CON-04-001, dated February 9, 2004). On behalf of the four participating Federal agencies, the EPA's Office of Radiation and Indoor Air (ORIA) is requesting that the SAB conduct the formal technical peer review of the draft MARSAME.

The following charge questions were posed to the SAB Rac's MARSAME Review Panel (U.S. EPA. 2007):

1) The objective of the draft MARSAME is to provide an approach for planning, conducting, evaluating, and documenting environmental radiological surveys to determine the appropriate disposition for materials and equipment with a reasonable potential to contain radionuclide concentration(s) or radioactivity above background. Please comment on the technical acceptability of this approach and discuss how well the document accomplishes this objective. In particular, please

a) Discuss the adequacy of the initial assessment process as provided in MARSAME Chapter 2, including the new concept of sentinel measurement (a biased measurement performed at a key location to provide information specific to the objectives of the Initial Assessment).

b) Discuss the clarity of the guidance on developing decision rules, as provided in MARSAME Chapter 3.

c) Discuss the adequacy of the survey design process, especially the clarity of new guidance on using Scenario B, and the acceptability of new scan-only and in-situ survey designs, as detailed in MARSAME Chapter 4.

d) Discuss the usefulness of the case studies in illustrating new concepts and guidance, as provided in MARSAME Chapter 7.

2) The draft MARSAME, as a supplement to MARSSIM, adapts and adds to the statistical approaches of both MARSSIM and MARLAP for application to radiological surveys of materials and equipment. Please comment on the technical acceptability of the statistical methodology considered in MARSAME and note whether there are terminology or application assumptions that may cause confusion among the three documents. In particular, please

a) Discuss the adequacy of the procedures outlined for determining measurement uncertainty, detectability, and quantifiability, as described in MARSAME Chapter 5.

b) Discuss the adequacy of the data assessment process, especially new assessment procedures associated with scan-only and in-situ survey designs, and the clarity of the information provided in Figures 6.3 and 6.4, as detailed in MARSAME Chapter 6.

c) Discuss the usefulness of the case studies in illustrating the calculation of measurement uncertainty, detectability, and quantifiability, as provided in MARSAME Chapter 7.

3) The draft MARSAME includes a preliminary section entitled Roadmap as well as seven appendices. The goal of the Roadmap is to assist the MARSAME user in assimilating the information in MARSAME and determining where important decisions need to be made on a project-specific basis. MARSAME also contains appendices providing additional information on the specific topics. Does the SAB have recommendations regarding the usefulness of these materials?

3. PRINCIPLES OF APPROACH FOR RESPONSE TO THE STATISTICS ELEMENTS OF THE CHARGE QUESTIONS

(This section is reserved for the present time for discussion on statistics that might need to be moved into the body of the text. - - -KJK)

Detailed discussions of statistical analysis related to experimental design and hypothesis testing permeate the otherwise general guidance for M&E surveys. The Panel response and comments are compiled in Appendix A on Statistical Analysis rather than scattering them throughout this review. Appendix A consists of an introduction to describe the view of the Panel, followed by specific reviewer responses based on these reviews. Related responses to individual charge questions are referred to Appendix A.

4. RESPONSE TO CHARGE QUESTION 1: PROVIDING AN APPROACH FOR PLANNING, CONDUCTING, EVALUATING AND DOCUMENTING ENVIRONMENTAL RADIOLOGICAL SURVEYS TO DETERMINE THE APPROPRIATE DISPOSITION FOR MATERIALS AND EQUIPMENT

4.1 <u>Charge Question 1:</u> ***The objective of the draft MARSAME is to provide an approach for planning, conducting, evaluating, and documenting environmental radiological surveys to determine the appropriate disposition for materials and equipment with a reasonable potential to contain radionuclide concentration(s) or radioactivity above background. Please comment on the technical acceptability of this approach and discuss how well the document accomplishes this objective.***

The MARSAME manual is an excellent technical document that adequately describes a robust assessment process. The Panel suggests some improvements t o (1) describe "alternate approaches or modification" for applying MARSAME, as discussed in Chapter 1, lines 50 – 56; and (2) design the manual for use by others – notably project managers -- than "the technical audience having knowledge of radiation health physics and an understanding of statistics" plus further capabilities described in Chapter 1, lines 187 – 194. One aspect that appears to be missing is the option of decontaminating the M&E as part of the process when considering alternate actions.

SUGGESTION 1-1: Separate the discussion that begins on l. 49 by creating a sub-section to present clearly the concept of simple alternatives to what may appear to the reader to be a major undertaking. Follow this paragraph with sufficient detail and references to later chapters to assure the reader that M&E that can be reasonably expected to have little or no radioactive contamination can be processed without excessive effort under the MARSAME system. One approach identified subsequently is applying standard operating procedures (SOP's). Categorization as non-impacted or as class 3 M&E based on historical data can lead to an appropriately simple process.

SUGGESTION 1-2: Insert a paragraph after l. 196 to address use by persons less skilled professionally than defined in a preceding paragraph. For such users, reference to Appendices B, C, and D, would be helpful. Adding another appendix that includes portions of the MARSSIM Roadmap and Chapters 1 and 2 could provide the suitable background information without requiring that all of MARSSIM be read. Presentation of training courses for managers and other generalists with responsibility for radiation surveys would be most helpful.

SUGGESTION 1-3: Insert a sub-section in Chapter 1 and also in appropriate subsequent chapters to consider various degrees of M&E decontamination as part of the available options associated with a MARSAME survey. Note that storage for radioactive decay is one option for decontamination.

4.2 <u>Charge Question 1a:</u> *Discuss the adequacy of the initial assessment process as provided in MARSAME Chapter 2, including the new concept of sentinel measurement (a biased measurement performed at a key location to provide information specific to the objectives of the Initial Assessment).*

The initial assessment process is adequate as described. That many measurements made throughout the MARSAME process could be biased is recognized. Some additional information sources and M&E categories may be helpful.

SUGGESTION 1a-1: The discussion in Chapter 2, lines 104 – 115 could include reviewing files (inspection reports, incident analyses, and compliance history) of currently and formerly involved regulatory agencies. Discussions with these agencies and their inspectors could also be fruitful.

SUGGESTION 1a-2: The listing of complexity attributes in Table 2.1 could include TOSCA materials and hazardous waste.

Sentinel measurements, as described for the initial assessment process of MARSAME have been commonly applied. They are rational and useful for obtaining an initial idea of the type and magnitude of radioactive contaminants. Because they were not randomly selected, by definition they are biased. These measurements and their applicability and limitations are well described in the document, and their use is clear. In fact, wider application appears practical.

SUGGESTION 1a-3: In Chapter 1, lines 253 – 259, MARSAME should recognize that Sentinel measurement is important because often it is all that is available historically for initial assessment (IA). Hence, considering it to be "limited data" can be misleading. Moreover, for Chapter 2, lines 277 – 280, design of a preliminary survey for radioactive contaminants to fill in knowledge gaps often depends on the availability of data from Sentinel measurements, and in some instances only further Sentinel measurements are possible.

4.3 <u>Charge Question 1b:</u> *Discuss the clarity of the guidance on developing decision rules, as provided in MARSAME Chapter 3.*

This chapter devoted to developing decision rules is most useful. The decision rules are admirably clear. Some additions will surely benefit the reader.

SUGGESTION 1b-1: The regulations or guidance for radionuclide clearance that define the action level discussed in Chapter 3, lines 118 – 120 are sufficiently important to be presented here, rather than in the obscurity of Appendix E. This information includes Table E.2 for regulations by DOE and Table E.3 by NRC. Additional information, for example, the guidance reported in Table 5.1 of NCRP (2002) on volumetric clearance standards, should also be given here to present the thinking of national and international standards and guidance groups.

SUGGESTION 1b-2: Information that describes the radioactive contaminant listed in lines 141 – 147 should include removable *vs.* fixed surface contamination. Further, insertion of a sub-section that discusses the planning implications of removable *vs.* fixed and surface *vs.* volumetric contamination would be helpful to the user.

SUGGESTION 1b-3: The discussion concerning measurement method uncertainty, detection capability, and quantification capability on lines 567 - 622 takes the MARSAME presentation from broad guidance to specific statistical tutorial. The tutorial raises certain questions for some general readers and other questions for some professionals. One approach is to maintain the less specific tome of MARSAME in these three sub-sections and refer to a detailed discussion of statistical aspects as given in SUGGESTIONS 1c-1 and 2a-1.

SUGGESTION 1b-4: Please clarify the following: Why is the MDC recommended for the MQO on lines 593 – 597 instead of the MQC? How does item #1 differ from item #3 on lines 609 – 617?

4.4 <u>Charge Question 1c:</u> *Discuss the adequacy of the survey design process, especially the clarity of new guidance on using Scenario B. and the acceptability of new scan-only and in-situ survey designs, as detailed in MARSAME Chapter 4.*

With the exception of Section 4.2, Statistical Decision Making, Chapter 4 is easily understood by the general reader. Classification of M&E is an effective approach and helpful. The Disposition Survey Design and Documentation sections are well prepared. Regarding statistical decision making, the concepts of hypothesis testing and uncertainty *per se* are readily understood. However, the concept of uncertainty with default significance levels and the resulting gray area and discrimination limits leading to minimum quantifiable concentrations are not so readily assimilated. An extended consideration of the statistical approach has been prepared and is attached to this review as Appendix A.

SUGGESTION 1c-1: Consider maintaining the same level of generalized guidance that pervades most of MARSAME in brief sub-sections that address statistical matters. Collect the mathematical discussion in a separate chapter, as proposed in SUGGESTION 2a-1. This type of discussion in Chapter 19, Measurement Statistics, of MARLAP should serve as example. Separation will serve both the specialist in statistics, who will appreciate the exposition in the new chapter, and those with less training in statistics who will follow the general import of the MASAME approach in the existing chapter.

4.5 <u>Charge Question 1d:</u> *Discuss the usefulness of the case studies in illustrating new concepts and guidance, as provided in MARSAME Chapter 7.*

Case studies can be useful for clarifying the MARSAME process and guiding the user. Although the Panel was informed by the MARSSIM Multi-Agency Work Group that Chapter 7 contains, not case studies, but made-up illustrative examples, these also can be helpful if created to represent actual situations. When an illustrative example fails to match a real situation, some changes in the presented example can improve it.

SUGGESTION 1d-1: Delete or replace the example for SOP use in Section 7.2. Given the good discussion in Section 3.10 for improving an SOP within the MARSAME framework, the example of applying SOP's at a nuclear power station appears to contribute little.

SUGGESTION 1d-2: The example in Section 7.3 of mineral processing of concrete rubble is instructive. The reader should be informed that many more measurement results than those listed in Table 7.3 are ordinarily obtained, but were not created here to conserve space. The radionuclide concentrations reported on lines 213 – 214 either should be confirmed as typical values or the reader should be cautioned that they are not. For the same reason, the AL taken from NUREG-1640 should be identified as a specific selection, not a general limit. Inserting boxes with interpretive comments would help the reader to understand the process and the decisions made.

SUGGESTION 1d-3: The sheer length of the 21-page example in Section 7.4 of the baseline survey of a rented front loader discourages its application. An introductory statement should explain that details are needed to describe the mechanism of the survey, but that the actual work is brief. This survey provides a good opportunity to present Sentinel measurements and the comparison of removable and fixed surface contamination. An actual case history undoubtedly would show these and also contain a table of survey measurements.

SUGGESTION 1d-4: The illustrative example headings would benefit from inclusion of a statement that they are demonstrating the MARSAME process.

5. RESPONSE TO CHARGE QUESTION 2: COMMENTS ON THE STATISTICAL METHODOLOGY CONSIDERED IN MARSAME

5.1 <u>Charge Question # 2:</u> ***The draft MARSAME, as a supplement to MARSSIM, adapts and adds to the statistical approaches of both MARSSIM and MARLAP for application to radiological surveys of materials and equipment. Please comment on the technical acceptability of the statistical methodology considered in MARSAME and note whether there are terminology or application assumptions that may cause confusion among the three documents.***

MARSAME contains tables and text that carefully compare the three documents and identify consistencies and differences. To those familiar with the three documents, application of the statistical methodology in MARSAME appears to match that used in MARSSIM and MARLAP to the extent observable over the existing wide range of applications.

A shift appears to have occurred from use of the Data Quality Objective (DQO) terminology of MARSSIM to the Measurement Quality Objective (MQO) of MARSAME, but the principle is comprehensible. It is clear that MARSAME has close connections to MARSSIM in surveys of M&E that were located at MARSSIM sites. The manual recognizes that M&E moved onto the site or used to process and survey the site subject to MARSSIM also may be considered under MARSAME. In addition, M&E unconnected with MARSSIM sites are subject to MARSAME.

5.2 <u>Charge Question # 2a:</u> ***Discuss the adequacy of the procedures outlined for determining measurement uncertainty, detectability, and quantifiability, as described in MARSAME, Chapter 5.***

The presentation for determining uncertainty, detectability, and quantifiability in Chapter 5, as well as aspects of this discussion in Chapters 4 and 6, follows the well-developed path in MARSSIM and MARLAP. Problems to be considered are whether comprehension and correct application by the user requires (1) previous reading of MARSSIM and MARLAP, and (2) the expertise and knowledge specified in Chapter 1, lines 189 – 194.

SUGGESTION 2a-1: Improve understanding the mathematically detailed statistical exposition in MARSAME by separating it in its entirety in a chapter that could be entitled "Review of Experimental Design and Hypothesis Testing". Appendix G can be included in this chapter. The chapter can be placed before Chapter 4 or after Chapter 6. All sections currently in Chapters 4 – 6 that discuss aspects of these items, including measurement uncertainty, detectability, and quantifiability, should be kept in place but revised to present generalized discussions of these matters, with reference to the technical discussions, equations, and tables in the new chapter.

SUGGESTION 2a-2: Refer to Appendix A for a detailed set of comments concerning the topics of experimental design, hypothesis testing, and the statistical aspects of uncertainty.

5.3 <u>Charge Question # 2b:</u> *Discuss the adequacy of the data assessment process, especially new assessment procedures associated with scan-only and in-situ survey designs, and the clarity of the information provided in Figures 6.3 and 6.4.*

The data assessment process is carefully presented and thoroughly explored. Much good advice is given and the examples are helpful.

Suggestions for statistical considerations are presented in Appendix A. The information presented in Figures 6.3 and 6.4 is clear, but minor changes are proposed. The need to address removable and fixed surface contamination and volumetric contamination in all chapters is emphasized.

SUGGESTION 2b-1: In Fig. 6.3, clarify the distinction of a MARSSIM-type survey by moving "Start" to immediately above the decision point "Is the survey Design-scan only or In-situ?" and then connecting this to the decision point "Is the AL equal to zero or background?". A "yes" leads to "Requires scenario B" and a "no" leads to "Disposition decision based on mean".

SUGGESTION 2b-2: In Fig. 6.4, for a more consistent presentation, insert a decision diamond after "Perform the sign test" and "Perform the WRS test" that says "Use scenario A", at both locations, followed by a "yes" or "no" leading to the two branches at both locations.

SUGGESTION 2b-3: Insert sub-sections in all chapters to address the implementation and assessment of survey processes that distinguish between surface and volumetric contamination (i.e., repeated measurement after surface removal) and between removable and fixed surface contamination (i.e., wipe test results compared to total surface activity). These types of contamination are described in Chapter 1, lines 127 – 152, but their implications are insufficiently considered throughout MARSAME. Concerns include difficulties in characterizing the depth of volumetrically distributed radionuclides, quantifying radionuclides that emit no gamma rays, and subsequent contamination of persons and surfaces by removable radionuclides.

5.4 <u>Charge Question # 2c:</u> *Discuss the usefulness of the case studies in illustrating the calculation of measurement uncertainty, detectability, and quantifiability as provided in MARSAME chapter 7.*

As stated in the response to Charge question 1d, case studies are invaluable in guiding the user through complex operations. The illustrative examples with which the case studies were replaced lack the realistic data accumulation that permits estimation of uncertainty. Excessively detailed calculations are provided on lines 579 – 628, 658 – 565, and 682 – 689. For discussions related to uncertainty, refer to the Appendix.

SUGGESTION 2c-1: Move the detailed calculations identified above to the separate chapter recommended for discussion of experimental design and hypothesis testing.

SUGGESTION 2c-2: Use the illustrative examples to demonstrate distinctions such as interdiction *vs.* release and scenarios A *vs.* B.

SUGGESTION 2c-3: Use the illustrative example in Sections 7.4 and 7.5 to demonstrate the benefit of smears (wipe tests) to determine removable surface contaminants. Experience suggests that the contaminant usually is in this form on M&E such as earth-moving equipment.

6. RESPONSE TO CHARGE QUESTION 3: RECOMMENDATIONS PERTAINING TO THE MARSAME ROADMAP AND APPENDICES

__Charge Question 3:__ ***The draft MARSAME includes a preliminary section entitled Roadmap as well as seven appendices. The goal of the Roadmap is to assist the MARSAME user in assimilating the information in MARSAME and determining where important decisions need to be made on a project-specific basis. MARSAME also contains appendices providing additional information on the specific topics. Does the SAB have recommendations regarding the usefulness of these materials?***

The Roadmap is crucial in guiding the reader through a document as complex as MARSAME. The appendices are useful in various ways, such as providing information compilations and statistical tables, and avoiding the need to seek this information in MARSSIM and MARLAP. Also necessary to the reader are the acronyms and abbreviations; symbols, nomenclature, and notations; and glossary. The following suggestions are intended to enhance their use.

SUGGESTION 3-1: Roadmap Figure 1 connects the MARSAME chapters in terms of the Data Life Cycle. Is it possible to draw an analogous connection with Roadmap Figures 2, 3, 5, 6, 7, and 8? At present, the only Roadmap Figures connected to each other are 2, 3, and 4, and 7 with 8.

SUGGESTION 3-2: Assist project managers by highlighting major operational decision points in the roadmaps.

SUGGESTION 3-3: Indicate in the body of the text that Appendices B, C, and D are useful overviews of the environmental radiation background, sources of radionuclides, and radiation detection instruments, respectively, for managers and generalists, although they are too general for the experienced health physicist to whom the manual is addressed.

SUGGESTION 3-4: Move Tables E.2 and E.3 and associated comments from Appendix E to Section 3.3, of which the tables should be an integral part.

SUGGESTION 3-5: Either move Appendix G into the new chapter on experimental design and hypothesis testing or indicate its relation to that new chapter.

SUGGESTION 3-6: Move the Glossary to the front to join the tables of acronyms and of symbols.

7. ADDITIONAL SUGGESTIONS

SUGGESTION C-1: Discuss decisions leading to selecting the degree of confidence, embedded in the choice of alpha and beta values, in a section of Chapter 3. Ultimately, the selection may be a matter of the acceptable uncertainty specified by the agency that sets the action level.

SUGGESTION C-2: Discuss the impact of survey cost and time frame on the MARSAME effort in a section of Chapter 2. Very brief or lengthy projects obviously need different designs. Data retention becomes important in long projects, especially if contractors replace each other.

SUGGESTION C-3: Discuss in a section in Chapter 6 the options to be considered and pursued when the plan proposed initially for M&E transfer must be rejected.

SUGGESTION C-4: Provide references (possibly to MARSSIM) for aspects of the MARSAME process that are discussed in much less detail than statistics. Among such topics are quality assurance (including validation and verification of results), the relation of radionuclide concentrations to radiation exposure (dose) for various radionuclide distributions in M&E, importance of sample dimensions or measurement frequency, and the effect of non-random variability in measurement (e.g., fluctuating geometry or monitor movement rate).

REFERENCES CITED

(Alphabetical and date sequenced listing of Author Last name, First name, Middle Initial, Title, Date, etc. To be refined in later versions - - - KJK).

.

.

Federal Register Notice Citations:

FR, Vol. 60, No. , March 7, 1995, p. 12555

FR, Vol. 72, No. , March 13, 2007, p.11356

FR, Vol. 72, No. 184, September 24, 2007, pp. 54255 – 54257.

.

.

FR, Vol. 72, NO. __, Date, pp. ____ - _____. (Charter Board Mtg. announcement to be added)

.

.

NCRP. 2002. Managing Potentially Radioactive Scrap Metal, Report #141, National Council on Radiation Protection and Measurements, Bethesda, MD 20814.

U.S. EPA. 2000 and 2001. ***"Multi-Agency Radiation Survey and Site Investigation Manual***" (MARSSIM). NUREG-1575, rev. 1; EPA 402-R-970-016, Rev. 1, DOE/EH – 0624, Rev. 1, August 2000 and June 2001 update

U.S. EPA. 2006. ***"Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual (MARSAME), Draft Report for Comment,"*** NUREG-1575, Supp. 1; EPA 402-R-06-002; DOE/EH-707, December 2006

U.S. EPA. 2007. Memo from Elizabeth A. Cotsworth, Director, Office of Radiation and Indoor Air (ORIA) to Vanessa Vu, Director, Science Advisory Board Staff Office, and entitled *"Review of the Draft Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual,"* October 23, 2007

.

U.S. EPA/SAB. 1997. ***"An SAB Report: Review of the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM),"*** Prepared by the Radiation Advisory Committee (RAC) of 5he Science Advisory Board , EPA-SAB-RAC-97-008, Sept. 30, 1997

U.S. EPA SAB. 2002. *"Panel Formation Process: Immediate Steps to Improve Policies and Procedures: An SAB Commentary,"* EPA-SAB-EC-COM-02-003, May 17, 2002.

U.S. EPA. 2004. ***"Multi-Agency Radiological Laboratory Analytical Protocols (MARLAP) Manual,"*** NUREG-1576; EPA 402-B-04-001A; NTIS PB2004-10521, July 2004

U.S. EPA/SAB. 2003a. ***"Consultation on Multi-Agency Radiation Site Survey Investigation Manual (MARSSIM) Supplements for Materials and Equipment (MARSAME): A Science Advisory Board Notification of a Consultation,"*** EPA-SAB-RAC-CON-03-002, Bebruary 27, 2003

U.S. EPA/SAB. 2003b. ***"Multi-Agency Radiological Laboratory Analytical Protocols (MARLAP) Manual: An SAB Review of the MARLAP Manual and Appendices by the MARLAP Review Panel of the Radiation Advisory Committee (RAC) of the U.S. EPA Science Advisory Board (SAB),"*** EPA-SAB-RAC-03-009, June 10, 2003

U.S. EPA/SAB. 2004. ***"Second Consultation on Multi-Agency Radiation Site Survey Investigation Manual (MARSSIM) Supplements for Materials & Equipment (MARSAME): A Science Advisory Board Notification of a Consultation,"*** EPA-SAB-RAC-CON_04-001, February 9, 2004

U.S. NRC. 1997. ***"A Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Survey,"*** Draft Report for Comment, Washington, DC, Nuclear Regulatory Commission (NRC) NUREG-1505, August, 1995.

Web-based Citations and Hotlinks

(e.g., Provided below as an illustrative example. Needs more work - - -KJK)

MARSSIM: http://epa.gov/radiation/marssim/index.html

MARSAME: http://www.marsame.org

MARLAP: http://epa.gov/radiation/marlap/index.html

APPENDIX A – STATISTICAL ANALYSIS – AN INTRODUCTION TO EXPERIMENTAL DESIGN AND HYPOTHESIS TESTING AND SPECIFIC COMMENTS ON STATISTICS

A-1 An Introduction to Experimental Design and Hypothesis Testing:

The general problem of design of a survey of the sort described in the MARSAME document involves the following issues:

(1) Understanding the error properties of the measurement instrument and how this can be manipulated (by changing counting times or performing repeated measurements of the same dose quantity, for example). Generally the measurement error can be well characterized by its standard deviation $\sigma_{M.}$ This value may be a constant (all measurements having the same standard deviation) or it may vary with radiation level (as in the behavior of an idealized radiation counter);

(2) Understanding the distribution of dose in the population of equipment or materials that are to be measured. This distribution can often be well characterized by a standard deviation σ_S which we may call the sampling standard distribution;

(3) Deciding upon the number of samples, N, from the distribution of activity that will be used in the detection problem;

(4) Specifying the null and alternative hypotheses to be examined;

(5) specifying the type I error (α) allowed;

(6) finding a specific alternative hypothesis (usually parameterized by a difference Δ=alternative – null value) for which the power to reject the null hypothesis takes a specified value 1-β.

From a statistical standpoint, designing an experiment means finding values of the sample size N and the detectable difference Δ that will control type 1 error and power, given the instrument's measurement error properties and the sampling dose distribution.

In MARSAME, the null and alternative hypotheses generally concern the true difference in levels between a potentially contaminated material or piece of equipment and the appropriate background reference. In Scenario A, the null hypothesis is that the M&E is at least as radioactive (over background) as some number called AL (the action limit), and the alternative is that the true concentration is less than AL. In Scenario 2 the null hypothesis is that the M&E is at the action level (which usually equals the background in scenario B) and the alternative hypothesis is that the M&E is over the AL.

When a single measurement is taken, the variance of that measurement will be equal to $\sigma_M^2 + \sigma_S^2$. In some cases, the sampling distribution and thus σ_S may be irrelevant to a MARSAME survey; for example, there may be no spatial variability (when there is only 1 level of radiation relevant to a small item for example). An important issue is how the error properties of the instrument behave when repeated measurements of the same equipment item or same portion of material are taken. For some measuring instruments, it may be reasonable to assume that the standard deviation of the average of N measurements of the same unit will have standard deviation equal to $\frac{\sigma_M}{\sqrt{N}}$. This will be the case in an idealized radiation counter, since performing additional measurements on the same sampling unit (item) is equivalent to increasing the count times for that unit. In other cases, there may be inherent biases in measurement instruments so that some or all of the measurement error is shared for all measurements. When sampling variability is present (so that σ_S is not zero), the variance of the mean of a random sample of N measurements of will have variance somewhere in the range $\frac{\sigma_M^2 + \sigma_S^2}{N}$ to $\sigma_M^2 + \frac{\sigma_S^2}{N}$. The first of these corresponds to measurement errors that are completely unshared and the second corresponds to measurement errors that are completely shared due, for example, to imperfect calibration (as in the "measured efficiency" of a monitor discussed in several places in the document). Generally, as more and more measurements are taken, the contribution of the sampling variance to the variance of the mean disappears, whereas some or all of the contribution of the measurement error may remain. The special case when 100 percent of a potentially contaminated material is measured may be regarded as the limit when N -> ∞. Again, some or all of the measurement error variance may still remain.

For most situations covered by MARSAME, the null hypothesis concerns the difference between background levels and the level of contamination of the M&E. Table 5.1 (in the current document) gives some special formulae used when counts in time follow a Poisson distribution (so that the variability of the counts of both background and the item of interest depends on counting time and radiation level). In general, the variance of the difference between sampled radioactivity and the estimate of background will require special investigation as a part of the survey design.

For simplicity, it is useful to denote the standard deviation of measurement minus background as σ, which refers to the standard deviation of the estimate (often termed the standard error) obtained from the entire measurement method (involving either single readings, multiple readings, scans of some or all of the material, etc.). This σ can be a relatively complicated function of the underlying measurement and sampling variability (which must include the uncertainties in the estimate of background) that may require careful study to quantify properly.

Once σ is determined, the power, 1-β, of a study will depend upon two other parameters, (1) the type I error rate α and (2) the size of the assumed true difference Δ. If the standard error of the estimate, σ, is the same for all radiation levels being measured, then the ratio Δ/σ determines power (otherwise a more complicated expression is used as in Table 5.1 of

MARSAME). For known σ,we may specify the "detectable difference Δ by fixing both the type I error α and the power 1-β and solving for Δ. In the MARSAME document, this detectable difference Δ is called the width of the "gray region". (Differences less than this Δ are only detectable with power less than the required 1-β and hence are "gray".) If the action level, AL, is defined to be the upper bound of the "gray region", then the lower bound (AL- detectable difference Δ) is called the "discrimination limit" (DL). Note that implicitly the detectable difference Δ and the detectable limit DL depend upon the power, type I error rate, and the standard error of the estimate σ. *One of the confusing aspects of the MARSAME document is that the DL is introduced long before the concept of power or type I error*.

The two scenarios (A and B) considered in the report both assume that the null hypothesis is at the action level, but differ in the direction of the alternative hypothesis and generally in the value of AL. Under scenario A, the alternative hypothesis is that the radiation level is less than the action level (which is the upper limit above background to be allowed) whereas under scenario B the alternative hypothesis is that the radiation level is greater than the action level (which is typically set to background). *Under scenario A the M&E is only deemed to be safe for release if the null hypothesis is rejected, whereas under scenario B the M&E is safe for release if the null hypothesis is **not** rejected.*

If under scenario A, for example, the true value of the radionuclide level (or level above background) is less than or equal to DL then the survey will have power 1-β to reject the null hypothesis that the true value is equal to the AL with type I error α. Under scenario B,if the value of true contamination-background is *greater* than the detectabledifference Δ, then the study will again have power 1-β to reject this null hypothesis at type I error rate α. Assuming that the standard error of the estimate, σ, does not depend upon the radiation levels being measured, the formula for the "detectable" Δ, given α, σ and power 1-β is

$$\text{Detectable difference}\, \Delta = (Z_{1-\beta} + Z_{1-\alpha})\sigma \qquad (1)$$

Where $Z_{1-\beta}$ and $Z_{1-\alpha}$ are the corresponding critical regions for the standard normal random variable. A somewhat more complicated formulae for Δ is needed when σ is not independent of radiation level as in Table 5.1; however, formula (1) gives a useful (conservative) approximation to the detectable difference if we choose σ to be at its maximum likely value for either the null or alternative hypothesis.

In general, the use of equation (1) for the detectable difference Δ requires that the estimate of contamination (measurement – background) be approximately normally distributed. For radiation counters with long count times and large values of N (when there is sampling variability as well as measurement variability), this assumption is usually quite appropriate. Because the width of Δ is (for fixed power and type I error) dependent on σ, it is important that an instrument or measurement technique (and sampling fraction for spatially distributed contamination) is selected which is sensitive enough (provides small enough σ) so that the detectable Δ meets requirements (for example so that the DL is not set to be too small in Scenario A, or that the upper range of the gray region is not set too high above background in Scenario B).

In some situations (non-normal distributions, short count times), the detectable Δ will be larger than described in equation (1) and more specialized statistical analysis may be needed. Such techniques as segregation according to likely level of contamination may improve the accuracy of equation (1), as will longer count times.

Hypothesis testing (accepting or rejecting the null hypothesis) involves comparing an estimate of contamination levels to a "critical value" (termed S_c in the report) which allows us to decide whether the observed estimate is consistent with the null value (at a certain type I error level) after taking account of the variability (i.e. σ) of the measurement. For Scenario A this value is equal to $S_c = AL - Z_{1-\alpha}\ \sigma$, and for Scenario B it is $S_c = AL + Z_{1-\alpha}\ \sigma$. By definition, power is the probability, as computed under the alternative hypothesis, of rejecting the null hypothesis; that is, the probability that the observed estimate is less than (for scenario A) or greater than (for scenario B) the critical value S_c.

If normality of the estimate is in doubt, then other approaches to hypothesis testing may be needed. For example, while for long count times the Poisson distribution can be approximated as normal for the purpose of hypothesis testing, for short count times specialized formulae (see section 5.7.1) may be needed to give a better approximation to the distribution of (measured-baseline) for an idealized radiation counter.

A-2 Specific Comments:

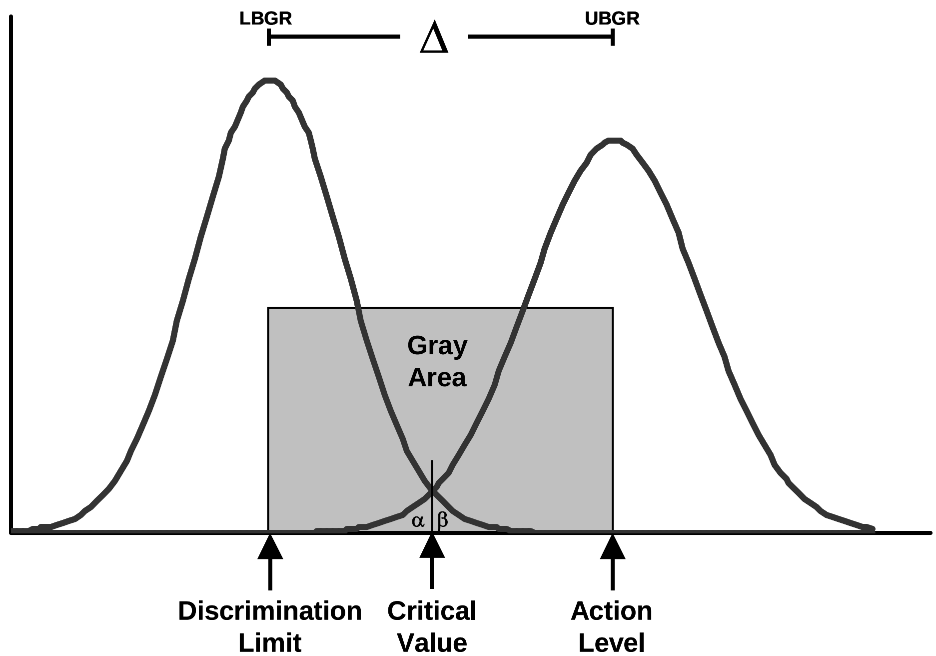
Section 3.8.1 describes "Measurement Method Uncertainty" but in somewhat more vague terms than above. The intent of this section could be better understood in reference to the suggested introduction to experimental design and hypothesis testing.

All of section 4 would be more comprehensible if it consistently referred back to the suggested introduction to experimental design and hypothesis testing.

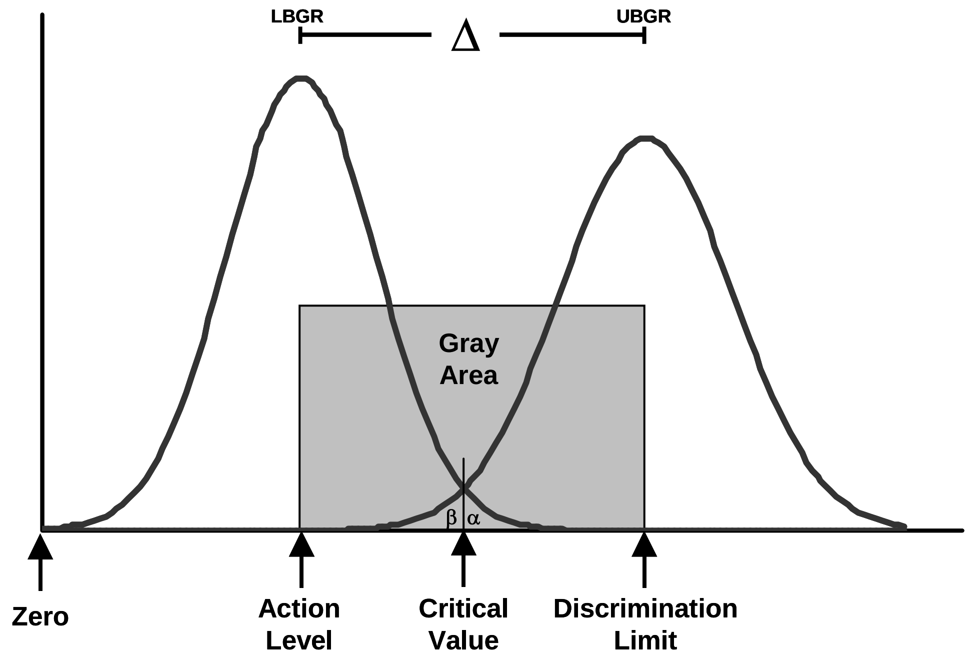
Section 4.1.1.2 gives a suggestion for how much of an impacted material should be scanned: it is not clear to what the σ value now refers (eq 4-1). This appears to be the measurement error standard deviation σ_M rather than the total standard deviation of the measurement method (measurement method uncertainty). Presumably, this is giving a recommendation that will keep the total measurement method uncertainty bounded for a given level of measurement error (σ_M).

The statistical concepts described earlier in this report are illustrated for the first time in Figures. 4.2 and 4.3 of MARSAME. It is unfortunate that even though the concepts shown of the figures all relate to net radioactivity, they are termed a "level", "value" or "limit". This could cause confusion and possibly be misinterpreted by someone who is preparing to establish a survey design. An expansion of these figures to include several additional parameters with some supplemental text would be helpful.

Suggestions for scenario A and B are presented. These embellished Figures with some additional text should also eliminate the need to repeat this information in Chapter 5 as in Figs. 5.2, 5.3, 5.4.



Scenario A
(H_0: Net Activity ≥ Action Level)



Scenario B
(H_0: Net Activity < Action Level)

As mentioned above, the Action Level for net excess radioactivity is used in defining the null hypothesis. However, the decision on accepting the null hypothesis is not based on the numerical value of net radioactivity at the Action Level. Rather, each sample is compared with the Critical Value shown in the Figures. This insures that the probability for rejecting the null hypothesis, when it is true, will not exceed α. The Discrimination Limit is the net radioactivity in the sample where the probability of accepting the null hypothesis, when it is false, is β (i.e. the power for rejecting the null hypothesis is $1-\beta$). The Gray area is the region of net radioactivity in the sample where the statistical power to reject the null hypothesis, when it is false, is less than $1-\beta$.

The intent of section 5.5 would be made more clear as dealing with the factors that impact the measurement error uncertainty σ as described in more general terms in the suggested review of experimental design and hypothesis testing. It appears, however, that σ_M (the standard deviation of a single measurement not taking into account spatial distribution of materials or the variability of the background) is being confused with the overall σ (total measurement method uncertainty taking these factors into account). It is Δ / σ, not Δ / σ_M, that determines the overall power of the experiment. The document should clearly differentiate these two σ 's.

Section 5.5.1, lines 289-293, seems to be confusing σ_m with σ_s . It is σ_s that, generally speaking, can be decreased by improving scan coverage (not σ_m if this includes "shared" error terms such as the "variance of measured efficiency"). The new terminology u_{MR} is apparently referring either to an estimate of the measurement error uncertainty σ_M or to overall σ but this is not made clear in this section (and the requirement that $u_{MR} \leq \sigma s/3$ makes no sense if σ_S can be reduced to 0 by improving scan coverage).

The comments on line 302-303 seem to require that u_{MR} be estimating the overall σ. Example 2 is confusing because the requirement that u_{MR} be a factor of 10 times smaller than Δ seems to assume that u_{MR} is an estimate of σ_M rather than the overall uncertainty σ (this would be a very stringent requirement indeed). Here one needs to focus not just on σ_M but rather on the total variability including σ_S . If σ_s can be reduced to zero by scanning all of a material why is such a stringent requirement made on σ_m?

Line 360 introduces new and not clearly defined uncertainties (u_c and φ_{MR}). Example 5 is unclear, and needs to be tied to some general design or hypothesis testing principles – it just comes out of thin air as it stands.

Section 5.6 is a good description of addressing measurement uncertainty σ_M in certain special cases. One thing that could be clarified is that σ_M is now referring to the error in measurement-background rather than just the error in the measurement itself. At other points in the document σ_m seems to refer rather to the variance of just the measurement.

Table 5.1 shows details of the calculation of a critical value specialized to radiation counters with Poisson errors in estimating both the background radioactivity level and the level of radioactivity in the measured M&E. Use of the Stapleton formulae seems to be giving an improvement correcting for non-normality of the Poisson distribution for small count times. It would be helpful here to note clearly that the MDC is the value of S_c for rejecting the null hypothesis (scenario B) of no excess radiation above background, i.e. by referring back to the suggested introduction to experimental design and hypothesis testing.

Section 5.8, Determining Measurement Quantifiability is a complicated way of saying that σ must be small enough (and hence Δ / σ large enough) in order for the measurement method to have good power not only to reject the null hypothesis that the level of radioactivity is at the AL for a reasonable Δ (width of the gray region), but also to give a reasonably narrow confidence limit for the estimated value, i.e. where the width of the confidence limit is small compared to the value of the AL.

One complication that is explicitly dealt with in the definition of the MQC is that the measurement method uncertainty, i.e. σ, generally will depend upon the (unknown) true level of radioactivity itself – for example a perfect counter has Poisson variance equal to its mean. Thus the MDC is just the value, y0, of the radioactivity level for which the ratio, $k=y0/\sigma$, is large (the document recommends k=10). If y0 is small relative to the action limit (between 10-50 percent of the AL is recommended), then it is clear both that (1) the detectable Δ will be small with respect to the action limit (i.e. the DL will be close to the AL) and (2) confidence limits around an estimated value of radioactivity will be narrow relative to the value of the AL. Saying this clearly helps to improve the intelligibility of this section.

Section 5.8.1 would be more intelligible if it first noted that it is giving a computation of the MDC, y0, for a fixed k by a formulae for σ that takes account of several factors which are combined into this one σ. These factors are the length of the reading time for the source, the length of reading time for the background, the true value of the background reading, and an estimate of the variance of a "shared" measurement error term, i.e. the measured efficiency of the monitor.

Section 6.2.1 has some confusing aspects: as described earlier, the gray region is defined in terms of the power and type I error of the test with a measurement method of total standard deviation σ. Sentences like "Clearly MDCs must be capable of detecting radionuclide concentrations or levels of radioactivity at or below the upper bound of the gray region" seem tautological if the gray region is defined in terms of detection ability; specifically in terms of power, type 1 error, and σ.

Section 6.2.3., lines 215-224, confuse by the statements about how individual measurement results can be utilized for scan-only measurements. The statement that "if disposition decisions will be made based on the mean of the logged data, an upper confidence level for the mean is calculated and compared to the UBGR" if not interpreted carefully (i.e. if one did a standard test such as Wilcoxan or t-test) would ignore any uncertainty component resulting from variability in the measurement process (i.e. measurement error shared by all measurements that constitute the scan). Only if σ_M has no shared components (or if they are very small) would it make sense to do a standard statistical test using the observed data alone. Specifically the sample standard deviation would underestimate the true measurement standard deviation σ if there is a shared uncertainty (such as errors in the estimate of counting efficiency) incorporated in σ_M .

The suggestion (line 60) that for MARSSIM type surveys the sample standard deviation can be used to generate a power curve also implicitly assumes that no shared measurement error components exist. But this contradicts the conclusion of line 223-224 that "Measuring 100% of the M&E accounts for spatial variability but there is still an uncertainty component resulting from variability in the measurement process." In fact, all the discussion of selecting and performing a statistical test, and drawing conclusions in the rest of Section 6 seems to be implicitly assuming that there are no shared errors from measurement to measurement: is this the intention? Was this what was being meant by the (confusing) discussion in Section 5.5.1, lines 289-293? For example, even if all measurements are less than the action level this might not really be enough information to conclude that the M&E meet the disposition criterion.

Suppose all measurements are only somewhat less than the action level but it is also known that the counting efficiency was not very well estimated. Ignoring the uncertainty in the counting efficiency could lead to the wrong conclusion in this case, if the uncertainty in the counting efficiency is indeed "shared error" over all the measurements. In many places in this document, errors in counting efficiency or other apparently shared measurement errors are mentioned (as on line 223-224), but this issue seems to be ignored in most of section 6. If the document is assuming that such shared errors are small enough to be ignorable then this should be stated explicitly. (see also footnote 4 on page 6-17)

One possible resolution is to assume that the measurement of background has exactly the same "shared" uncertainties (counter efficiencies etc) as does the measurement of the radioactivity level in the M&E. In this case, the shared uncertainties will be subtracted out when the background is subtracted from the level measured in the M&E. If this is what is meant then this should be stated clearly (and this should be highlighted in the any initial "review of experimental design and hypothesis testing" when discussing the various components included in σ).

APPENDIX B –ACRONYMS AND ABBREVIATIONS

(Use only those terms that are applicable to the subject content being discussed and apply as follows. This template needs revision, with new terms to be added and others to be dropped - - - KJK)

A	Scenario A
AL	Action Limit
α	Type I Error
AM	Arithmetic Mean
AR	Absolute Risk
β	Beta
B	Scenario B
Bq	Bequerels
Bq/m^2	Bequerels/ Square meter
Bq/m^3	Bequerels/Cubic meter
$1-\beta$	Specified Value (1 minus Beta)
CDC	Centers for Disease Control and Prevention
CFR	Code of Federal Regulations
Co	Chemical symbol for cobalt (^{60}Co isotope)
CQ	Charge Question (CQ1, CQ 2, CQ3,)
Δ	Difference =Alternative – Null value) also the Detectable Difference
DFO	Designated Federal Officer
DL	Discrimination Limit
DLC	Data Life Cycle
DoD	Department of Defense (U.S. DoD)
DOE	Department of Energy (U.S. DOE)
DQO	Data Quality Objective
EAR	Excess Absolute Risk
EPA	Environmental Protection Agency (U.S. EPA)
FR	Federal Register
FGR-13	Federal Guidance Report 13
GM	Geometric Mean
GMC	Geometric Mean Coefficient
GSD	Geometric Standard Deviation
Gy	gray, SI unit of radiation absorbed dose (1Gy is equivalent to 100 rad in traditional units)
H	Chemical symbol for Hydrogen (^{3}H isotope)
H_o	???
HPGE	???
IA	Initial Assessment
∞	Infinity
I	Chemical symbol for Iodine (^{131}I isotope)
ICRP	International Commission on Radiological Protection
ICRU	International Commission on Radiation Units and Measurements, Inc.
keV	kiloelectron Volts

MARLAP	Multi-Agency Laboratory Analytical Protocols
MARSAME	Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual
MARSSIM	Multi-Agency Survey and Site Investigation Manual
M&E	Materials and Equipment
MDC	Measurement Data Uncertainty
MQC	Measurement Quality Uncertainty
MQO	Measurement Quality Objectives
mSv	milli-Sievert
N	The Sample Size (N measurements, for instance)
NAI	Sodium Iodide Detectors
NAS	National Academy of Sciences (U.S. NAS)
NCRP	National Council on Radiation Protection and Measurements
NRC	Nuclear Regulatory Commission (U.S. NRC)
OAR	Office of Air and Radiation (U.S. EPA/OAR)
ORIA	Office of Radiation and Indoor Air (U.S. EPA/OAR/ORIA)
PAG	Protective Action Guide
Pu	Chemical symbol for Plutonium (^{239}Pu Isotope)
QA	Quality Assurance
QC	Quality Control
QA/QC	Quality Assurance/Quality Control
R	roentgen
RAC	Radiation Advisory Committee (U.S. EPA/SAB/RAC)
rad	Traditional unit of radiation absorbed dose in tissue (a dose of 100 rad is equivalent to 1 gray (Gy) in SI units)
rem	Radiation equivalent in man; traditional unit of effective dose equivalent (equals rad x tissue weighting factor) (100 rem is equivalent to 1 Sievert (Sv))
RERF	Radiation Effects Research Foundation
R/h	Roentgen per hour; traditional measure of exposure rate
RR	Relative Risk
SAB	Science Advisory Board (U.S. EPA/SAB)
σ	Standard deviation
σ_M	Standard Deviation of Measurement Error
σ_S	Standard Deviation of Sampling Distribution
S_c	Critical Value
SI	International System of Units (from NIST, as defined by the General Conference of Weights & Measures in 1960)
Φ_{mr}	The relative upper bound of the estimated measurement method uncertainty μ_{mr},
Type I	Error
Type II	Error
Tl-208	???
u	Uncertainty (e.g., $u_{c)}$, and
μ_{mr}	Estimated Measurement Method Uncertainty
φ	Uncertainty (e.g., $\varphi_{MR)}$

US	United States
WLM	Working Level Months
WRS	(A statistical test)
y_O	???
Z	Critical Regions (e.g., $Z_{1-\alpha}$, or $Z_{1-\beta}$)

APPENDIX C –MARSAME TYPOS AND CORRECTIONS

(To be moved to a memo from report to a memo from the RAC MARSAME Review Panel DFO to the Multi-Agency Work Group via the ORIA Staf fOfficxe - - - KJK)

xxix line 504 power?
522 delete one (
xxxi 561 delete one)
567 delete one (
xxxiv 671 Technetium (sp.)
xxxv 676 delete (duplicates 675)
1-3 80 change "activity concentrations" to "area activity" or leave as is but change "Bq/m^2" to "Bq/m^3" and add "and area activity (Bq/m^2)
3-9 194 non-radionuclide-specific (insert dash)
4-5 Figure 4.1a replace second "Large" by "Much Larger"
Figure 4b. replace second "Small" by "Equally Small or Smaller"
5-21 523 value in denominator should be 0.4176 (see line 527)
527 plus should be behind square root of 87
5-53 1148 delete 2nd period
6-6 142 insert "to" behind "likely"
6-11 280 insert "that" behind "determine"
6-13 329 insert "that" behind "demonstrate"
6-23 474 and 482 critical value in symbols table is not in italics (italicized k is coverage factor)
7-10 210 Tl-208 should be beta/gamma, not just beta, with gamma-ray energy in next column
B-6 151 maximize, not minimize
D-9 219 what does "varies" mean?
D-36 849 for LS spectrometer, insert (alpha) on first line of column 2 and (gamma) for the HPGE and NaI detectors
F-1 26 delete (FRER)

End of Document