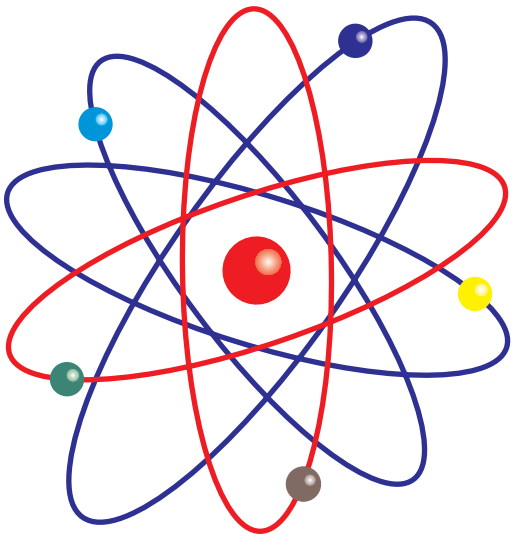
# Follow-up Special Study of

# Nuclear Material Control and Accountability Programs Across the Department of Energy



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### Abbreviations Used in This Report

| | |
|---|---|
| D&D | Decontamination and Decommissioning |
| DOE | U.S. Department of Energy |
| DP | DOE Office of Defense Programs |
| EM | DOE Office of Environmental Management |
| IAEA | International Atomic Energy Agency |
| INEEL | Idaho National Engineering and Environmental Laboratory |
| INFCIRC | Information Circular |
| LANL | Los Alamos National Laboratory |
| LANMAS | Local Area Network Material Accounting System |
| LLNL | Lawrence Livermore National Laboratory |
| MC&A | Material Control and Accountability |
| NMMSS | Nuclear Materials Management and Safeguard System |
| NRC | Nuclear Regulatory Commission |
| R&D | Research and Development |
| SNM | Special Nuclear Material |
| SO | DOE Office of Security and Emergency Operations |
| TID | Tamper Indicating Device |

# Executive Summary

## Scope

The Secretary of Energy's Office of Independent Oversight and Performance Assurance (Independent Oversight) conducted a follow-up special study of selected aspects of Department of Energy (DOE) nuclear material control and accountability (MC&A) programs. Previous Independent Oversight special studies in 1995 and 1998 identified a number of longstanding weaknesses in the MC&A programs that had not been adequately addressed, including inadequately measured materials, ineffective accounting practices, and inadequate treatment of holdup (i.e., materials stuck in process equipment and piping).

The purpose of this special study was to assess improvements that DOE has made and recommend enhancements that DOE could make to account more accurately for plutonium and enriched uranium. Independent Oversight closely coordinated with the Office of Security and Emergency Operations (SO), DOE Headquarters and operations office line management, and MC&A contractor personnel throughout this study and solicited their input on the focus areas for the evaluation.

## Results

At most DOE sites, MC&A programs have improved substantially and have addressed longstanding weaknesses. Since the 1995 special study by Independent Oversight's predecessor organization, DOE sites have measured many previously-unmeasured nuclear materials, strengthened material surveillance, stabilized and/or processed several types of nuclear materials that could not previously be measured, obtained new measurement equipment and standards, reduced inventories of unmeasured scrap, and resolved issues that had prevented some physical inventories. DOE and contractor MC&A programs have made noteworthy progress in measuring and accounting for holdup, which had previously been a weakness at several sites. For example, DOE sites have measured holdup in process equipment using techniques taught at DOE training courses and have cleaned holdup out of several areas.

Although improvement efforts were often slow to get started, the pace of improvements has accelerated at most DOE sites in the past two years. For example, the three DOE national nuclear weapons laboratories—Los Alamos, Livermore, and Sandia—have all made significant improvements in their MC&A programs as a result of the broader efforts to improve safeguards and security at the national laboratories directed by Energy Secretary Richardson. While some corrective actions are ongoing at several sites, Independent Oversight inspections indicate that most sites now have satisfactory MC&A programs.

Despite these significant improvements, this Independent Oversight follow-up review identified a few areas that warrant more attention. Most notably, increased senior management attention is needed to resolve longstanding and increasingly important issues related to irradiated nuclear fuel, including U.S. enriched fuel being returned from foreign countries. Oversight studies in 1995 and 1998 identified concerns about implementation of MC&A programs for irradiated nuclear fuel, and these same concerns exist today. The current DOE policy does not provide practical direction for implementing irradiated nuclear fuel safeguards. In the absence of clear requirements, current approaches for performing MC&A functions for irradiated nuclear fuel still vary widely in effectiveness. The most significant issues are with physical inventories and measurements. Since each site with irradiated nuclear fuel uses a different inventory approach, the assurance that the inventory is correct varies across the DOE.

Measurement of irradiated nuclear fuel is difficult, time-consuming, and expensive, but the importance to the national non-proliferation effort is significant. Over the next several years, large quantities of irradiated nuclear fuel will be returned to the U.S. from foreign countries, and these returns warrant prompt and significant management

attention. As part of a U.S. non-proliferation effort, DOE, with the assistance of the U.S. Department of State, is arranging for the return of large quantities of irradiated fuel containing about 2000 kilograms of special nuclear material (SNM) from up to 41 foreign countries, including Argentina, Brazil, Columbia, Congo (formerly Zaire), Greece, Iran, Israel, Pakistan, Slovenia, South Africa, South Korea, Taiwan, Thailand, and Turkey. The return of this material is an important positive step in U.S. nonproliferation efforts because it enables the U.S. to regain positive control over material that could potentially be used by foreign countries. However, the methods currently used to verify that the SNM is present are not sufficient to assure that SNM has not been diverted. With the current and planned approaches for receiving this fuel, it is possible that fuel rods could be placed in the permanent repository and never be measured to verify the SNM content, and thus a discrepancy or substitution could go undetected. So far, DOE's efforts to address this issue through research and development (R&D) and policy direction have not been well coordinated. The risks associated with safeguards programs for irradiated nuclear fuel, particularly foreign fuel returns, need to be carefully analyzed to determine whether they are acceptable to senior DOE management.

DOE policy states that DOE requirements must be comparable in effectiveness to those of other U.S. government agencies with similar nuclear materials, such as the Nuclear Regulatory Commission (NRC). This follow-up review found that, generally, DOE requirements for MC&A are similar to those of the NRC and, in most cases, are comparable in effectiveness. However, there are two important areas where DOE policy is less effective:

- **Prompt loss detection.** The NRC has more stringent requirements for quantitative prompt detection of SNM losses and includes process monitoring, which is more effective than DOE's administrative controls. As a result, NRC-licensed facilities achieve more accurate and timely material balances than most DOE facilities with processing areas.

- **Scrap inventory controls.** The accuracy of the inventory at many DOE sites is adversely impacted by large amounts of poorly measured materials such as scrap. NRC has requirements for timely recovery of scrap and measurement uncertainties for scrap. DOE does not have corresponding requirements. In the absence of a specific requirement to recover scrap, DOE sites often accumulate significant quantities of poorly-measured materials. NRC requirements prevent such accumulations.

In addition, there are other differences that DOE should evaluate to determine whether DOE would benefit from modifying its requirements to more closely match those of the NRC, such as time limits for reconciliation of physical inventories. There are also aspects of DOE requirements, such as confirmation measurements during inventories, that should be evaluated to determine whether they provide a significant enough safeguards benefit to warrant their cost.

The DOE-wide and facility-specific accounting systems, the Nuclear Materials Management and Safeguard System (NMMSS) and the Local Area Network Material Accounting System (LANMAS), respectively, are functioning, and LANMAS has met a DOE-wide need. LANMAS has grown out of an R&D project and is now fully functional at nine DOE sites. While some aspects of the two systems require further development, the current deficiencies do not degrade the effectiveness of safeguards programs. However, the deficiencies in the two systems and the interface between the two cause frustration to the users and lead to duplication of effort and unnecessary inefficiencies in the accounting, reconciliation, and reporting processes. While progress is being made and upgrades are continuing, the efforts to ensure compatibility have not yet been successful. Additional attention and strong program management direction for both LANMAS and NMMSS and the interface between the two systems could help to alleviate these inefficiencies. Furthermore, several important DOE sites have not accepted LANMAS, and there is no indication that a single DOE-wide system will ever exist at the facility level for MC&A inventory reporting.

In addition to the DOE-wide issues for management attention discussed above, continued and increased attention is needed for the MC&A program at the Y-12 Plant. Notwithstanding the significant progress at most sites, deficiencies in the Y-12 MC&A program persist. While improvements have been made, the Y-12 Plant has not performed measurements for a full physical inventory in several material balance areas, and it has large amounts of poorly-measured scrap material and holdup. The weaknesses in the MC&A program are partially attributable to the 1994 shutdown of operations to address safety concerns; some of the process equipment needed for MC&A functions has not been

restarted since then. The Y-12 Plant has developed a corrective action plan to address MC&A weaknesses identified in a 1999 Independent Oversight inspection report. Recently, the Y-12 Plant developed a plan to conduct an inventory in November 2000 and reconcile the results by January 2001. If effectively accomplished, the upcoming inventory and reconciliation will be a major step forward in addressing the longstanding problems at the Y-12 Plant. However, additional attention, including definitive milestones and funding commitments, will still be needed to address other longstanding issues related to holdup measurements and material surveillance.

## Conclusion and Recommendations

The overall conclusion of this follow-up study is that MC&A programs have improved substantially in the past few years at most sites, but increased management attention is needed in some specific areas. The most immediate concerns involve the MC&A program at the Y-12 Plant and the methods for measuring foreign fuel returns.

DOE needs to ensure that the planned inventory and reconciliation are completed on schedule and that corrective action plan for the previous Independent Oversight MC&A findings at the Y-12 Plant are fully and effectively addressed on an expedited basis. Senior DOE managers at Headquarters and the Oak Ridge Operations Office are aware of the problems at the Y-12 Plant and are working to develop a consensus resolution.

In light of the longstanding inability to develop and issue clear policy related to irradiated nuclear fuel and the increased foreign fuel returns to DOE, increased senior DOE management attention is needed to ensure that DOE Headquarters enhances policy to explicitly address MC&A requirements for irradiated nuclear fuel. While the continuing efforts to solicit field input and develop consensus approaches are important, further delays are not prudent, and Headquarters decisions and direction are needed to establish a policy and to direct the field and R&D efforts to a common goal.

Although a less immediate safeguards concern, policy enhancements and improvements in the national and facility-specific accounting systems can improve the effectiveness of DOE MC&A programs while facilitating more efficient use of limited safeguards and security resources.

In addition to the site-specific improvements needed at the Y-12 Plant, which are covered in the Independent Oversight 1999 inspection report of the Y-12 Plant, the Independent Oversight team developed three general recommendations. These are summarized in Table ES-1. Volume 2 of this report provides more detailed recommendations and technical information.

**Table ES-1 – Summary of Recommended Enhancements**

**1. Establish a comprehensive policy and risk acceptance process for irradiated nuclear fuels.**

- A clear policy should be established that considers the safeguards risks and costs/operational impacts of measuring irradiated nuclear fuel at various points in the life cycle.
- Foreign returns should be explicitly addressed in the policy and provided a higher level of protection because of the increased potential for diversion.
- R&D efforts should be accelerated and coordinated by DOE Headquarters.
- Plans for ultimate disposition of irradiated nuclear fuel should be re-examined to identify and incorporate MC&A provisions, including provisions for measurements prior to permanent storage.

**2. Reevaluate DOE policies to strengthen certain requirements to enhance the effectiveness of MC&A programs.**

- SO should conduct a careful analysis of the safeguards benefits, costs, cost savings, and worker safety implications of a number of potential enhancements to DOE orders. The analysis should include the life cycle of materials such as scrap to ensure that all costs and benefits are considered.
- Specific changes that should be considered include: establishing requirements for prompt loss detection, establishing a comprehensive scrap control program, eliminating the requirement for physical inventory confirmation measurements, requiring verification measurement of all non-tamper-indicating items at the time of the physical inventory, adopting NRC MC&A definitions where DOE does not currently provide a definition, implementing a requirement for item monitoring, establishing measures control human error rates, requiring a periodic estimation of error variances for bulk measurement systems and sampling techniques, establishing a firm policy on bias correction, requiring reconciliation of physical inventories within a specified time, and establishing a clear policy for MC&A records retention.
- In the longer term, DOE should reassess its approach to MC&A orders to include development of: (1) an MC&A order with clear performance objectives; (2) a format and content guide for MC&A plans; (3) acceptance criteria to assist DOE in evaluating contractors' MC&A plans; and (4) a defined MC&A plan approval process.

**3. LANMAS and NMMSS have improved MC&A reporting in the DOE complex during the past 12 months, and increased management attention is essential to ensure long-term success.**

- SO, in coordination with Defense Programs, needs to determine whether the benefits of making LANMAS the single, DOE-wide accountability system outweigh the costs and operational impacts of converting the remaining DOE sites to LANMAS.
- LANMAS development, currently funded as an R&D program, should transition to a permanent operational activity program funded as part of the DOE operations budget.
- SO should strengthen and enhance their efforts to address LANMAS and NMMSS compatibility issues.
- SO should enhance communications between the developers and users of LANMAS and NMMSS.
- SO should continue their efforts to coordinate software upgrades.
- SO should exercise leadership in ensuring that LANMAS development is responsive to overall DOE objectives, such as compatibility with International Atomic Energy Agency requirements.

# 1.0 Introduction

The Secretary of Energy's Office of Independent Oversight and Performance Assurance (Independent Oversight) performed a follow-up special study of nuclear material control and accountability (MC&A) during fiscal year 2000. Independent Oversight was established as a direct report to the Secretary of Energy in May 1999 and is the focal point for Department of Energy (DOE) independent oversight in safeguards and security, cyber security, and emergency management. Independent Oversight performs inspections and reviews of DOE sites to determine whether the sites have effectively implemented DOE policies in these areas. Independent Oversight also evaluates DOE policies in these areas to determine whether the policies are clear and understood by the field, and whether the policies are sufficient to achieve the DOE goals of protecting the public, workers, the environment, and national security. When warranted, Independent Oversight conducts special studies of a particular aspect of safeguards and security, cyber security, or emergency management on a DOE-wide basis.

Accurately accounting for special nuclear material (SNM) is technically challenging and, historically, DOE has experienced difficulties and exhibited weaknesses in the MC&A arena. Recognizing the problems, Independent Oversight's predecessor organizations published several studies in MC&A, most notably the 1994-1995 study entitled *Increasing Fissile Material Assurance in the Department of Energy* and a 1998 follow-up study entitled *Followup Review of Fissile Material Assurance in the Department of Energy Complex*. These reports on these reviews are available on the Independent Oversight Web Page at http://tis.eh.doe.gov/iopa.

**This Independent Oversight study focused on identifying ways to improve DOE's ability to accurately account for plutonium and high-enriched uranium.**

Over the past six months, Independent Oversight conducted a follow-up special study of selected aspects of MC&A. The purpose of this study was to identify improvements that DOE can make to enhance its ability to accurately account for SNM, including plutonium and high-enriched uranium.

In its new role as a direct report to the Secretary, Independent Oversight places more emphasis on providing line management (program offices, operations offices, and managing contractors) and the security policy organization—the Office of Security and Emergency Operations (SO)—with information that will help to resolve longstanding weaknesses and/or improve the effectiveness or efficiency of safeguards and security policies and programs. Consequently, this review focused on identifying potential corrective actions for specific problem areas and analyzing selected policies and current DOE initiatives to determine whether improvements are needed.

## Background

MC&A refers to the measures that are taken to ensure that DOE sites accurately account for and control the SNM in DOE's possession. MC&A encompasses measurement programs, accounting systems and records, physical inventories, inventory reconciliation and evaluation, and periodic reporting of the amounts of fissile materials to sitewide and national databases.

**Effective material control and accountability (MC&A) is essential to protection of special nuclear material (SNM).**

DOE is required by law—the Atomic Energy Act of 1946 (as amended in 1954)—to ensure that SNM is properly protected and accounted for. In addition to the legal mandate, effective MC&A programs are needed to ensure that DOE knows precisely how much material it has and where all materials are located.

**A 1995 study identified weaknesses in MC&A programs.**

A 1995 study by Independent Oversight's predecessor office highlighted problems and identified a number of short-term and long-term opportunities for improvement that were intended to help address MC&A issues. The report noted that it would take years to fully address the longstanding and diverse problems and recommended long-term enhancements, such as a steering group, to ensure that MC&A issues were communicated to senior management and resolved. In 1996, the DOE Office of the Inspector General reviewed MC&A programs and found problems similar to those noted in the 1995 report. The Inspector General report concluded that DOE should accelerate efforts to implement the improvements outlined in the 1995 report. DOE actions in response to the 1995 special study report included establishment of a working group to serve as a forum for discussing issues and recommending solutions and the initiation of a DOE-wide measurements assessment project.

Although some progress was made in the 1995 to 1997 timeframe, inspection results indicated that DOE continued to have weaknesses in measuring certain types of materials, performing adequate inventories, establishing effective policies, and other MC&A functions. Because of the relatively slow progress at some sites, Independent Oversight's predecessor organization conducted a follow-up review of MC&A in 1998 that focused on identifying obstacles to timely enhancement of MC&A and determining what additional enhancements were needed. The 1998 review determined that DOE sites had made progress toward addressing some of the challenges associated with improving MC&A. The most notable achievement was the completion of the measurements assessment project, which provided an assessment of the adequacy of measurements for DOE fissile materials. Various DOE sites had made progress in stabilizing and measuring certain materials and in procuring needed measurement equipment.

**A follow-up study in 1998 concluded that weaknesses in MC&A persisted.**

Although some progress had been made, the 1998 review concluded that some weaknesses in MC&A had not been adequately addressed, and DOE had not yet achieved the needed level of confidence in its nuclear material inventory. About half the DOE sites had weaknesses that were similar to those identified in the 1995 report, such as inadequate measurements and deficient inventory practices. The 1998 report identified factors that contributed to unnecessary delays in resolving MC&A weaknesses, such as lack of management support and delays in issuing revisions to MC&A orders and guidance.

## Scope and Approach

This 2000 follow-up special study was conducted in two major phases. In the first phase, Independent Oversight reviewed inspection results and other data, such as reports generated by the Nuclear Materials Management and Safeguard System (NMMSS) database. The Independent Oversight team identified actions that had been taken since the 1998 follow-up review to address weaknesses in MC&A, including the specific weaknesses and opportunities for improvement noted in the 1998 report. The purpose of this first phase was to determine what additional data was needed and where Independent Oversight could best focus the second phase of its oversight efforts.

**Independent Oversight selected four focus areas for review.**

Based on the review conducted in the first phase of the special study, Independent Oversight identified four focus areas to be reviewed in detail in the second phase:

- Measuring and accounting for nuclear material holdup
- Safeguards for irradiated nuclear fuels
- Comparability of DOE and Nuclear Regulatory Commission (NRC) regulations
- Compatibility of national and facility-specific computerized accountability systems.

These focus areas were selected based on a preliminary analysis of longstanding problems and recent improvements. Three of the focus areas (holdup, irradiated fuel, and compatibility of accounting systems) have persisted as problem areas since 1995, indicating that obstacles to progress have not been addressed. In addition, all four of these focus areas affect multiple sites and highlight aspects of DOE policy that warrant further attention.

**Independent Oversight solicited MC&A input from line management and policy-development organizations.**

Independent Oversight closely coordinated with SO, the program offices that manage the major DOE nuclear sites (the Office of Defense Programs [DP] and the Office of Environmental Management [EM]), DOE operations office personnel, and contractor MC&A personnel in the field throughout this study. During the early stages of planning, Independent Oversight contacted personnel from SO and from selected DOE sites to discuss the scope of the study and to solicit input about potential topics to select for detailed review. During the field visits, the Independent Oversight team solicited input from field personnel about potential corrective actions. Personnel from SO were briefed at various times throughout the review and accompanied Independent Oversight on selected field visits.

## Organization of This Report

Volume 1 of this report provides a management-level summary of the status of MC&A programs (Section 2) and a summary assessment of each of the four focus areas. It also includes recommendations for program enhancement (Section 3). Appendix A of Volume 1 identifies the Independent Oversight team members who managed and conducted the special study, and the SO personnel who supported the study from its inception.

Volume 2 provides detailed technical information, a more technical evaluation of each focus area, and important references. The intent is to provide SO and technical specialists in the field with an integrated evaluation of the status and obstacles for each of the focus areas that can serve as a basis for discussion and resolution of specific issues.

# 2.0 Status of MC&A Programs

The status of DOE MC&A programs is presented in two subsections. The first discusses the overall status based on inspection results and interviews conducted during this special study. The second subsection discusses the four focus areas of this special study.

## 2.1 Overall Status of MC&A Across DOE

MC&A programs at most DOE sites have improved substantially, and many longstanding weaknesses have been addressed. Some of the significant accomplishments since the 1995 special study are:

- Stabilization activities have begun at several sites (Rocky Flats, Hanford, and the Savannah River Site), enabling these sites to perform MC&A functions that previously could not be accomplished because the material could not be handled safely.
- The Savannah River Site completed measurement of unmeasured materials and has resumed limited processing activities.
- Los Alamos National Laboratory (LANL) completed measurements of previously unmeasured highly enriched uranium materials using active well coincidence and neutron multiplicity counters.
- Lawrence Livermore National Laboratory (LLNL) reorganized its MC&A organization to provide higher visibility for MC&A activities and instituted a program to fabricate calibration standards.
- LANL and LLNL developed effective programs for timely detection of losses in their nuclear material processing areas.
- Some scrap materials have been shipped to commercial vendors for recovery.
- The Y-12 Plant is currently transitioning to a new accountability system. The transition is scheduled for completion in fiscal year (FY) 2001.
- Uranyl nitrate solutions were packaged and shipped out of the Rocky Flats site.
- Extensive holdup measurements were completed at Portsmouth Gaseous Diffusion Plant and Hanford and are in progress at Rocky Flats.
- Rocky Flats and the Idaho National Engineering and Environmental Laboratory (INEEL) have successfully conducted decontamination and decommissioning (D&D) activities in identified buildings and completed comprehensive material balances.
- LANL and Rocky Flats have shipped plutonium wastes (at measured values) to the Waste Isolation Pilot Plant.
- Hanford, LANL, and LLNL have resolved previously identified issues concerning the conduct of physical inventories.
- DOE Headquarters issued a long-delayed DOE MC&A order revision.

**DOE programs for measuring and accounting for nuclear materials have been improved significantly.**

With these improvements, DOE has "turned the corner" in addressing longstanding and pervasive problems. Before 1995, DOE sites had thousands of kilograms of unmeasured or poorly measured SNM. Many problems in measuring SNM have been addressed or are well on their way to being addressed through ongoing programs. While there are still some isolated problems (such as irradiated fuel and scrap and holdup at the Y-12 Plant, which

are discussed later in this report), DOE sites have addressed most of the major problems with unmeasured material identified in the 1995 study. Although corrective actions are ongoing at several sites, Independent Oversight inspections indicate that only the Y-12 Plant currently has a less-than-satisfactory MC&A program.

Although improvement efforts were often slow to get started, the pace of improvements accelerated at most DOE sites in the past two years for a variety of reasons. Most notably, Energy Secretary Richardson directed a series of enhancements in safeguards and security across DOE and improved line management accountability for safeguards and security performance. These actions have significantly improved physical security and cyber security and resolved longstanding problems, such as protection of classified nuclear weapons parts. DOE has taken action to clarify responsibilities and ensure that DOE and contractor managers are accountable for implementing effective safeguards and security programs.

**Senior DOE management support has prompted many improvements, particularly at the national weapons laboratories.**

As part of this broad effort, senior managers at many DOE sites have implemented efforts to enhance MC&A programs. The effect of their increased emphasis is particularly evident at the national weapons laboratories—LANL, LLNL, and Sandia. All three have made significant improvements in their MC&A programs. For example, LANL has a very effective prompt-loss detection capability that includes such features as regular cleanout of equipment to recover materials. In addition to the Secretarial initiatives, several DOE sites, including Savannah River, Hanford, and Rocky Flats, have devoted significant effort and resources to resolving identified MC&A weaknesses.

**The Y-12 Plant continues to have significant weaknesses in MC&A.**

Notwithstanding the improvements at most sites, the Y-12 Plant has not performed measurements for a full physical inventory in several material balance areas, and has large amounts of poorly measured scrap material and holdup. The weaknesses in the MC&A program are partially attributable to the 1994 shutdown of operations to address safety concerns; some of the process equipment needed for MC&A functions has not been restarted since then. However, the line management chain for the Y-12 Plant (DP, Oak Ridge Operations Office, and the contractor) has not been effective in taking actions that could have alleviated the impact of the shutdown on the MC&A program. The Y-12 Plant has developed a corrective action plan to address MC&A weaknesses identified in a 1999 Independent Oversight inspection. However, funding for resources and equipment, as well as meeting milestones for some aspects of the plan, has not been firmly established.

Independent Oversight has continued to track the progress of the Y-12 Plant in addressing the identified weaknesses. In June 2000, Independent Oversight issued a memorandum to the Oak Ridge Operations Office requesting information on the status of corrective actions at the Y-12 Plant. The response was reviewed as part of an August visit to the Y-12 Plant by members of the Independent Oversight MC&A special study team.

Subsequent to the June Independent Oversight memorandum, the Y-12 Plant developed a specific plan for conducting a physical inventory by November 2000 and completing the reconciliation by January 2001. For some types of materials, this inventory will use engineering estimates because a measurement is not feasible with the current equipment and recovery capabilities. The Y-12 Plant has made substantial progress toward completing the engineering estimates and the inventory. For example, non-destructive assay measurements of uranium in 245 tanks has been completed and validated.

If fully and effectively implemented, the planned inventory and reconciliation will be a major step forward in addressing the longstanding problems at the Y-12 Plant.

Although the inventory is an important step, continued attention is needed at the Y-12 Plant to ensure that all identified concerns are fully addressed. Particular attention is needed to ensure that the measurement uncertainties for some measurement systems are supported by adequate data, complete additional holdup measurements, ensure that sufficient measurement personnel are available, complete the calculation for the Limit of Error of Inventory Difference, resolve inventory differences from the November 2000 inventory, and address weaknesses in material surveillance. In some cases (e.g., material surveillance and holdup), Y-12 corrective action plans do not result in a timely resolution and are dependent on funding commitments. Corrective actions for material surveillance and holdup are not scheduled to be completed until FY 2002 and FY 2005, respectively.

DOE and contractor line management for the Y-12 Plant are cognizant of the concerns at the Y-12 Plant and are currently working to develop a consensus resolution. For example, personnel from the Office of the Chief of Defense Nuclear Security—the security organization within the National Nuclear Security Administration—visited the Y-12 Plant and indicated their intent to work with DP and site management to resolve longstanding MC&A problems. Independent Oversight will continue to track progress at the Y-12 Plant and conduct follow-up reviews to determine and report that status to DOE Headquarters and site management.

## 2.2 Status in the Selected Focus Areas

### Nuclear Material Holdup

As a result of process operations, equipment and piping may contain SNM that is difficult to remove until the equipment is disassembled and cleaned out. This material is referred to as holdup. DOE needs to know approximately how much SNM is in holdup, not only to adequately protect both the material and the workers near the equipment, but also to determine whether SNM is missing. Holdup generally was not a problem at most DOE sites until the mid-1980s, becoming more serious in the early 1990s. With the end of the Cold War, many processes ceased operation, and DOE as a whole no longer needed to reprocess and recycle materials for the nuclear arsenal. The holdup material was identified as a significant concern in 1995, and although the 1998 study concluded that some sites had effectively resolved holdup concerns, other sites had not made sufficient progress.

**Most DOE sites have made noteworthy progress in addressing holdup concerns.**

The results of this 2000 follow-up review indicate that DOE sites have made noteworthy progress in addressing holdup concerns, although two sites have additional work to complete. Most DOE sites have developed adequate programs to measure and protect holdup. DOE sites generally have specifically addressed holdup in their D&D plans, including provisions for material surveillance and measurements as the material is cleaned out of buildings. As DOE efforts have progressed, DOE sites have used data from the recovery of nuclear materials to validate and improve measurement techniques, thus reducing the uncertainties in the estimates of current inventories of holdup.

The progress at DOE sites can be attributed to site management's commitment of resources to procure equipment, perform the needed measurements, and maintain periodic surveillance of the material in holdup. In addition, a course developed by the DOE Nonproliferation and National Security Institute and taught at LANL has contributed to a number of improvements in holdup measurement programs. This course provides useful techniques and training in non-destructive assay for measuring of nuclear material holdup.

**Measurement of Holdup at the Rocky Flats Site**

Although most sites have adequately addressed holdup concerns, the Y-12 Plant continues to have substantial quantities of material in holdup that have not yet been adequately measured. Also, Rocky Flats will not be able to complete measurements until D&D activities are near completion.

- As discussed previously, the MC&A program at the Y-12 Plant has a number of weaknesses that need to be addressed, including problems with measuring holdup. For example, when process equipment that contained holdup was removed, accountability records were not always adjusted, and holdup in new equipment has not been evaluated.

- Rocky Flats has estimated the amounts of holdup and has active campaigns under way to measure holdup to support D&D activites. One processing building will not be complete for several years, but Rocky Flats has measured all areas where elevated amounts of holdup are expected and added the quantities to the accounting records.

These two site-specific concerns were identified in previous Independent Oversight inspection reports and are being addressed and tracked as part of the DOE corrective action plan process. At Rocky Flats, the interim measures and planned long-term corrective actions are adequate to address the holdup concerns, if fully and effectively implemented. At the Y-12 Plant, corrective action plans have been developed and some actions are under way, such as efforts to add measurement staff. However, some aspects of the plan are not funded, and firm milestones for completion have not been established. Furthermore, some aspects of the resolution of the holdup issue at Y-12 depend on restarting certain recycling and scrap recovery processes. Some compensatory measures, such as enhanced daily administrative checks, are in place at the Y-12 Plant to mitigate the risks associated with poorly-measured materials.

**Nuclear material holdup is being adequately addressed at most DOE sites.**

Overall, DOE and contractor MC&A programs have expended considerable effort and made noteworthy progress in addressing holdup. Most holdup concerns identified in 1995 and 1998 have been addressed. The site-specific corrective action plans are adequate to address the few remaining concerns in all cases except Y-12, where the milestones are not firmly established. Senior DOE and contractor management are well aware of the problems at Y-12 and are working to develop milestones for their resolution as part of the broader concern with the Y-12 MC&A program. Independent Oversight will continue to follow up on corrective action plans to verify that they are effectively implemented and timely.

## Safeguards for Irradiated Nuclear Fuels

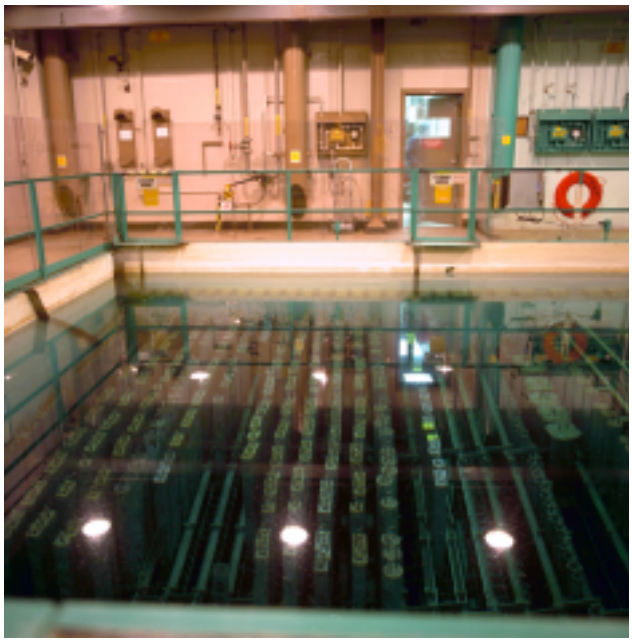
DOE has large quantities of irradiated nuclear fuel that was used in nuclear research reactors or production reactors and that contains plutonium and/or enriched uranium (including enrichments up to 93 percent U-235). The vast majority of these materials are in long-term storage at four DOE sites: Savannah River, INEEL, Hanford, and Argonne-West. In addition, DOE has sent U.S. enriched fuel to 41 foreign countries, including Argentina, Brazil, Columbia, Congo (formerly Zaire), Greece, Iran, Israel, Pakistan, Slovenia, South Africa, South Korea, Taiwan, Thailand, and Turkey. While in these countries in excess of 30 years, the fuel was used to power research reactors and became irradiated. Some of this foreign fuel has been returned to the U.S. and is stored at either Savannah River or INEEL.

**Concerns related to irradiated nuclear fuels were noted in 1995 and 1998.**

Several MC&A concerns with measurement and protection of irradiated fuels were identified as emerging concerns in the 1995 and 1998 studies. Before the 1990 timeframe, most irradiated fuel from non-commercial U.S. reactors was processed and purified, and the SNM content was eventually measured. With the shutdown of certain DOE processes, it was not possible to process spent fuel, and large amounts accumulated in storage areas (e.g., INEEL currently has over 30,000 items of irradiated fuel).

At the time of the 1998 study, a particular concern was that DOE did not have a clear policy that could be effectively implemented for irradiated fuel. Much of that irradiated fuel was historically exempt from certain MC&A requirements because it was considered self-protecting; that is, the radiation levels were so high that special equipment and shielding were needed to handle the fuel, and thus unauthorized removal of the SNM was considered extremely difficult and unlikely. Over time, however, the radiation levels have decreased. Thus, some irradiated fuels, while still radioactive, are no longer self-protecting.

**DOE policy does not provide practical direction for irradiated nuclear fuel.**



Underwater Storage Basin at the Savannah River Site

Other than the exceptions for self-protection, DOE policy does not clearly distinguish between requirements for irradiated fuel and other types of SNM. Therefore, according to DOE policy, irradiated fuel is subject to MC&A requirements, such as measurement and regular inventories. However, it was not practical for sites to effectively implement those requirements for a number of technological and operational reasons:

- The lack of measurement capability and equipment at most facilities and for most materials, which are in a variety of storage configurations and containers
- The high radiation exposure that workers would incur in handling and measuring irradiated fuel
- The lack of suitable storage facilities that could accommodate material movements and measurements (fuel is typically stacked in storage pools or placed in underground storage, where it is not easily accessible)
- The lack of records and visible identification for some assemblies (e.g., identification markings for items were cut off or no longer readable)
- Degradation of the assemblies (e.g., some have broken or corroded over time, with pieces accumulating on the floors of spent fuel storage pools).

Since the 1995 and 1998 studies, DOE organizations have made some attempts to resolve issues related to applying MC&A functions to irradiated fuel. For example, in October 1997, a subgroup of the Fissile Material Assurance Working Group was formed to propose DOE policy for the accountability and measurement of irradiated nuclear fuel. However, the subgroup did not reach a consensus, and DOE has been unable to resolve specific issues raised by Independent Oversight reports and DOE field elements. As a result, there has been no change in formal policies, even though the current policy is widely recognized to be extremely difficult and very expensive to implement, for the reasons listed above.

In addition, despite significant discussion in the MC&A community about irradiated nuclear fuel, very little formal, practical guidance has been issued on the subject. Recommendations from SO indicate that accountability values for non-self-protecting irradiated nuclear fuel should be based on measured values or other valid means. While the SO recommendations do not specifically state that measurements must be made, they do state: "When technology exists, it should be used to assay irradiated nuclear fuel and to validate reactor burnup/enrichment calculated estimates without causing unacceptable radiation exposure to personnel." This general guidance is not sufficiently specific to ensure consistently effective implementation.

**In the absence of clear requirements, current approaches for irradiated nuclear fuel vary widely in effectiveness.**

In the absence of clear Headquarters policy and direction, DOE field elements have the responsibility and authority for determining the adequacy of their contractors' MC&A measures for irradiated nuclear fuel. The results of Independent Oversight inspections and data gathered during this review indicate that current approaches for performing MC&A functions for irradiated nuclear fuel still vary widely in effectiveness. Some materials have been measured and are regularly inventoried. Other materials, however, have never been measured and are not included in an effective inventory process (e.g., only items that are accessible are included in the inventory samples).

Although the approaches are not consistently effective and policy is not adequate, it is important that decisions about revising policy be made carefully and with full consideration of the safeguards risks and the cost and operational impacts. Because of the physical protection measures and administrative controls in place, it would be extremely difficult for a single individual to divert a strategic quantity of SNM from irradiated fuel stored at DOE sites. The costs of implementing programs to regularly and rigorously inventory irradiated nuclear fuels could be very high, and the operational impacts would be significant. For example, in response to an EM inquiry concerning the safeguarding of irradiated fuel, the DOE Idaho Operations Office indicated that a new facility for fissile material measurement would be required, with an estimated construction cost of $300 million and life cycle costs exceeding $1 billion for 35 years of operation.

**Measurements of irradiated nuclear fuel are expensive and time-consuming, and equipment is not readily available.**

**Calibrating Equipment for Measuring Irradiated Fuel**

Similarly, measurements are expensive and time-consuming, and equipment is not readily available. Currently, the measurement principles are well known, some equipment is being field tested, and some systems are under development. Only Savannah River has a system in place, and that system is only used for one type of fuel. In general, the technology exists to measure irradiated nuclear fuel, with varying degrees of system performance depending on the type of fuel being measured, quantity of nuclear material present, and the irradiation characteristics. However, technology is not currently available for measuring some types of irradiated nuclear fuel.

One specific concern is that in some cases, the current plans do not provide for measurement at any time in the future. If any material were diverted, it would never be detected. Furthermore, according to current plans, irradiated nuclear fuel will be stored at DOE sites until it can be transferred to a permanent repository when one is available (e.g., Yucca Mountain). Before transfer to a permanent repository, this fuel would be packaged for shipping and permanent storage. Except for the melt and dilute process for aluminum spent fuel, there are currently no clear plans or provisions for measuring the irradiated nuclear fuel at the time of packaging.

**Measurements could be made at certain points in the fuel life cycle before ultimate disposition.**

Although a comprehensive measurement program may be impractical, MC&A measures could be applied at various times in the life cycle of irradiated nuclear fuel; this would not be prohibitively expensive and would address a significant concern with the current disposition plans. For example, measuring irradiated nuclear fuel at the time of packaging could ensure that the material placed in storage contains the assumed quantities of SNM and thus that a diversion has not occurred. Similarly, measurements could be performed after irradiated nuclear fuel is received by a site and before it is placed in a storage pool or other location where handling it would be difficult or involve significant radiation exposure to workers. However, with the exception of some materials at Savannah River, there are no measurements of materials as they are received and no capability in place to perform such measurements.

**Irradiated nuclear fuel that is being returned from foreign countries is a particular concern.**

The most significant concern is with irradiated nuclear fuel that is being returned from foreign countries. For domestic sites, even without measurements, DOE can be reasonably confident that a significant quantity of SNM has not been diverted because DOE can verify that physical security measures and administrative controls have been in place since the irradiated nuclear fuel was removed from a reactor. This concept is often referred to as "continuity of knowledge." However, continuity of knowledge cannot be assured for irradiated nuclear fuel being returned from foreign countries for a variety of reasons—government regimes may have changed, some of the fuel is difficult to identify due to obscured serial numbers, some fuel has deteriorated or broken, and so on. Various MC&A personnel have proposed that the U.S. assume that other countries have continuity of knowledge if they have implemented an International Atomic Energy Agency (IAEA) physical protection standard (INFCIRC 225) of material as a basis for accepting returns without a measurement of the actual content. While this approach may be justifiable for certain trusted countries, the technical basis for accepting continuity of knowledge is not generally supportable because other countries' continuity of knowledge requirements are not mandatory and have not been in force throughout the time that the material has been out of DOE's control, or similar reasons.

**Large quantities of irradiated nuclear fuel are to be returned to the U.S. in the next few years.**

There is currently good reason to increase the emphasis on irradiated nuclear fuel that has been in foreign custody. As part of a U.S. non-proliferation effort, the U.S. is negotiating with the countries that currently have certain types of U.S. enriched nuclear fuel assemblies (e.g., those that contain enriched uranium) to accelerate the return of all such fuel. As a result of this effort, it is expected that Savannah River and INEEL will receive large amounts (over 10,000 assemblies, with an equivalent of over 2000 kilograms of U-235) through 2009. The importance of the non-proliferation effort obligates DOE sites to accept this material even if they are not fully equipped to meet all of the associated MC&A requirements, such as a quantitative measurement upon receipt. The return of this material is an important positive step in U.S. nonproliferation efforts because it enables the U.S. to regain positive control over material that could potentially be used by foreign countries.

Although the risks are significantly different, DOE policy does not currently distinguish between irradiated nuclear fuel that has been in foreign custody and fuel that has not, and the two DOE sites that accept foreign fuel use different approaches. Savannah River has been proactive in developing and implementing a measurement system but now measures only 10 percent of each foreign research reactor shipment to be stored at the Receiving Basin Offsite Fuels facility. INEEL does not perform measurements of any irradiated nuclear fuel returns from foreign countries and does not have equipment in place to do so. However, INEEL is considering having INEEL personnel travel to the shipping country and make a measurement before the material is shipped back to the U.S.

**Efforts to develop equipment and perform measurement are not well coordinated.**

The existing programs to measure nuclear fuels, develop measurement equipment through research and development (R&D), and perform measurements are not well coordinated across DOE and are not driven by clear Headquarters policy and goals. Sites develop their own systems, and funding is sought through various paths. In the absence of formal policy on safeguarding irradiated nuclear fuel, each site has made different assumptions about risk acceptance and requirements for final disposition and has implemented programs accordingly.

For the most part, DOE operations offices have made the decisions regarding risks associated with irradiated nuclear fuel, both DOE and foreign returns. Other than Site Safeguards and Security Plans, which do not normally provide details about irradiated nuclear fuel, there are no formal provisions for communicating the risks to DOE senior managers at Headquarters or to other U.S. government agencies to ensure that the risks are acceptable.

**Current and planned practices do not assure detection of a foreign country's attempt to divert nuclear materials.**

With the current practices, DOE is implicitly accepting certain risks, such as a foreign country substituting "dummy" fuel rods, plates, or assemblies for the real ones. If such an event were attempted, there is no point in the process where such a substitution would be detected with certainty. Current DOE site practices would not reliably detect a substitution on receipt. Once received at the sites, the periodic inventory and measurement practices are not sufficient to determine the amount of SNM in an item. Similarly, as noted, there is currently no provision that would ensure that a diversion would be detected before the irradiated nuclear fuel is placed in permanent storage.

Overall, continued and increased management attention is needed to resolve longstanding and increasingly important issues related to irradiated nuclear fuel. While important to the national non-proliferation effort, the return of foreign fuels warrants prompt and significant management attention. The methods historically and currently used to verify that the SNM is present are not sufficient to provide high assurance that SNM has not been diverted before the returned material is placed in a permanent repository. The risks associated with irradiated nuclear fuel, and foreign returns in particular, need to be carefully analyzed to determine whether they are acceptable to DOE senior management. Further, risk assessment methods, efforts to measure irradiated nuclear fuel, and R&D efforts for measurement technologies need to be coordinated as part of a comprehensive, Headquarters-driven strategy and policy that ensures effective protection across DOE.

## DOE/NRC Comparability

DOE and the NRC have the same overall objective of protecting SNM from theft or diversion, and both organizations must ensure that they accurately account for SNM, including plutonium and highly enriched uranium. Despite these similarities, there are differences between DOE and NRC operations and facilities. For example, DOE has many old facilities that are undergoing D&D and has large quantities of SNM in long-term storage that is no longer needed for the defense mission. Also, in the mid-1990s, DOE adopted an approach to requirements that gave the field elements more flexibility in their approach to meeting safeguards and security requirements. As a result of such factors, DOE and NRC requirements are not identical. However, DOE policy specifically requires that DOE requirements be "comparable in effectiveness" to those of other agencies with similar materials, such as the NRC. DOE policy specifically states that "requirements, procedures, and standards for SNM safeguards must be at least equivalent in their effectiveness to policies, procedures, and standards established by the NRC."

**Independent Oversight compared MC&A requirements to identify potential policy improvements.**

Independent Oversight included a comparison of DOE and NRC MC&A requirements in this follow-up special study because DOE had not previously conducted such a comparison. The intent of the Independent Oversight review was not to identify all of the individual differences in the specific requirements. Rather, the intent was to identify those aspects of DOE policy that do not provide the same level of protection as those of NRC. DOE can then focus on improving those aspects to enhance its ability to protect SNM effectively and efficiently.

In comparing DOE and NRC requirements, it is important to recognize that differing requirements do not necessarily imply better or worse protection. The overall effectiveness of a safeguards and security program relies on multiple layers of protection that includes MC&A, physical security, and protective force response. As part of DOE policy, DOE sites must perform vulnerability assessments to ensure adequate protection of SNM.

**Although similar, DOE's requirements for prompt loss detection and scrap inventory quality differ from NRC's.**

This review concluded that many aspects of DOE requirements are similar in intent and effectiveness to those of the NRC, including nuclear material accounting, reporting to NMMSS, calculation of the uncertainty of the material balance, training, internal transfers, performance testing, and occurrence reporting. In some areas, such as training, the DOE and NRC requirements are similar but DOE programs typically have more formality and rigor. For example, the DOE Nonproliferation and National Security Institute has developed a number of effective training courses in selected MC&A program elements; both DOE and NRC personnel have benefited from these courses.

In other areas, such as physical inventories of vaults, NRC and DOE use different approaches. For example, DOE allows extended inventory frequencies of up to five years based on the implementation and quality of DOE-specified detection and delay mechanisms. Although the approaches are different, the two programs are comparable in effectiveness, and the differences appropriately reflect the different missions. For example, DOE's mission includes long-term storage of SNM, and DOE allows alternative approaches (e.g., extended inventory frequencies where enhanced detection mechanisms are in place) that provide equivalent protection while reducing inventory costs and radiation exposure to workers; such alternative approaches are not used at NRC sites.

Independent Oversight identified two important areas where DOE requirements are not as stringent as those of the NRC and the level of protection is not comparable:

- **Prompt Loss Detection.** The NRC has more stringent requirements for quantitative prompt detection of SNM losses. The NRC requires process monitoring, which is more effective than DOE's administrative controls.

- **Scrap Inventory Quality.** The accuracy of the inventory at many DOE sites is adversely impacted by large amounts of poorly measured materials, such as scrap. The NRC has requirements for timely recovery of scrap and measurement uncertainties for scrap. DOE does not have corresponding requirements. In the absence of a

specific requirement to recover scrap, DOE sites often accumulate significant quantities of poorly-measured materials. NRC requirements prevent such accumulations.

In addition to these two areas, Independent Oversight identified other areas of less-significant difference in DOE and NRC requirements. Areas where DOE could benefit from modifying its policy to be more like that of the NRC include:

- **Developing a performance-based DOE order.** DOE initiated development of a performance-based order and acceptance criteria in 1998, but has not finalized a complete package of requirements and guidance. A performance-based MC&A order with acceptance criteria, MC&A plan format and content guide, a defined MC&A plan approval process, and a schedule for completion would enable DOE sites to focus on the MC&A performance objectives. As a result, facilities would have more freedom to use the MC&A implementation approach that is most cost effective in meeting the performance objectives.

- **Eliminating the requirement for physical inventory confirmation measurements.** In many cases, the DOE confirmation measurement programs associated with physical inventories do not add to the overall effectiveness of the layered safeguards at the facilities. Eliminating confirmation measurements could reduce radiation exposure, minimize physical inventory time, reduce measurement equipment costs, and allow a better allocation of safeguards and programmatic resources. The NRC has never considered confirmation measurements at the time of the physical inventory to be an essential safeguards element.

- **Revisiting the statistical sampling policy for verification measurements.** The NRC has a higher level of fissile material assurance than DOE, in part because of the NRC policy for measuring non-tamper-indicating items at the time of the physical inventory. While DOE allows statistical sampling for measurement of these items, the NRC requires that all of these items be measured. To achieve comparability with the NRC, DOE needs to close the material balance around process areas with measured values for all materials when practical.

- **Adding definitions.** To be consistent with the NRC and to help eliminate confusion in terminology, DOE should include NRC MC&A terms and upgrade the status of DOE definitions from "guidance" to an "order."

- **Implementing item monitoring.** Implementing the NRC approach to item monitoring would move DOE from after-the-fact loss detection at the time of the physical inventory and administrative checks to a quantitative loss detection program with specified goals for capability and timeliness.

- **Monitoring human errors.** DOE does not distinguish human errors in data from other sources of error, while the NRC requires human errors to be specifically and separately identified and monitored. By focusing on human errors, DOE would improve the capability to evaluate and respond to inventory differences.

- **Periodically estimating bulk calibration and sampling variability.** DOE should require error variances to be estimated at specified times rather than only when process or material changes affect the values. This approach would help ensure that error estimates reflect current conditions.

- **Implementing bias correction.** While DOE and NRC require biases to be determined and included in evaluating inventory control, DOE would improve fissile inventory assurance by instituting a requirement for correcting biases for both items and total inventory (as NRC currently does).

- **Ensuring timely reconciliation**. DOE does not specify a timeframe for completing reconciliation of the physical inventory. To ensure timely closure of material balances, DOE should specify, similar to the NRC, a maximum time after the start of the ending inventory to close the material balance, calculate an inventory difference, and reconcile and adjust the books to the physical inventory.

- **Extending records retention.** Although DOE requires an audit trail from source data to accounting records, there is no specified time period for maintaining records as required by the NRC. Appropriate records retention times should be stated to ensure traceability and quality of data.

Section B of Volume 2 discusses the items in more detail and includes a table (Table B.3.10) summarizing the benefits of each and the sites affected, as well as the potential obstacles that would need to be considered and addressed.

**The effects of strengthening DOE policy need to be evaluated, particularly for scrap recovery and prompt loss detection.**

Some additional costs and operational difficulties would be associated with strengthening DOE requirements in areas such as scrap recovery and prompt loss detection. However, there would also be some cost savings and long-term efficiencies. For example, enhanced requirements for prompt loss detection (e.g., process monitoring) would entail some costs but might also allow other requirements (e.g., reducing inventory frequency for process areas) to be relaxed, thus saving on resources. Similarly, prompt recovery of scrap would be difficult at some sites because they lack processing equipment, but it would forestall continuing problems resulting from failure to process scrap. (For example, DOE is expending enormous resources to develop and implement methods for safely handling and processing legacy materials.) The safeguards benefits, costs, cost savings, and worker safety implications should be analyzed carefully before any change in policy.

Independent Oversight also identified aspects of DOE requirements that should be reexamined to determine whether their safeguards benefit is commensurate with the resources expended. One example is the DOE requirement for confirmation measurement programs as part of physical inventories. As discussed above, this DOE requirement provides little added safeguards value, but it requires time and resources and can involve some level of radiation exposure to workers. Eliminating this requirement would make these resources available for other safeguards functions, such as more verification measurements.

Overall, DOE requirements and NRC requirements are comparable in effectiveness, as required by DOE policy. However, DOE needs to reevaluate its MC&A policy in a few areas, including prompt loss detection and scrap inventory controls. Strengthening and improving requirements in these areas could provide long-term operational and cost benefits as well as enhance safeguards.

## Compatibility of Accountability Systems

The NMMSS and the Local Area Network Material Accounting System (LANMAS) are computerized accountability systems that are very important to MC&A; the accuracy of nuclear material accounting data is crucial to demonstrating to the U.S. and international organizations that all nuclear material is adequately accounted for. NMMSS, the national system for accounting for nuclear materials, has been in continuous use since 1963. All U.S. sites, both DOE and NRC, must periodically report their inventories of nuclear material to NMMSS. NMMSS program management was transferred to SO in November 1999. An Oakland Operations Office contractor maintains the NMMSS program and is responsible for performing various reconciliation and reporting functions.

In the early 1990s, DOE recognized that legacy accounting systems needed to be replaced and that a standardized approach would benefit the DOE complex. LANMAS began as an R&D project at LANL to help sites perform certain MC&A functions and reporting requirements such as transactions, tracking containers and tamper-indicating devices, performing material balances, and reporting data to NMMSS. LANMAS development was transferred to Savannah River in 1996. In July 1998, Savannah River was the first site to use LANMAS to report to NMMSS. Currently, nine sites use LANMAS as their official nuclear materials accounting system, and several other sites are planning to use it.

**LANMAS has met an important need but has not been accepted by several major DOE sites.**

This Independent Oversight review concluded that LANMAS has met an important need within DOE. In the 1990s, every site used a different accounting system, several of which were archaic and not Y2K compliant, and every site had to develop its own methodology for reporting information to NMMSS. LANMAS has many useful features and has helped several sites improve their ability to report to NMMSS in a more timely manner. For example, LANMAS has a month-end closure routine and is designed to reject transactions that do not meet established criteria.

Although now used by nine sites, LANMAS has not been adopted by all DOE sites. In 1996, the Deputy Secretary requested all sites to consider the

implementation of LANMAS in future material accounting upgrade or replacement efforts. In October 1999, SO issued a memorandum identifying LANMAS as a mechanism within the Department to capture item-level inventory information to enhance standardization of reporting at the site level and to NMMSS, and to improve nuclear material accounting. However, five important sites with large quantities of SNM do not use LANMAS: LANL, LLNL, Sandia-New Mexico, the Pantex Plant, and the Y-12 Plant. Pantex has indicated that it would migrate to LANMAS if funding (about $500 thousand) were provided; however, that request for funding is assigned a low priority because the current Pantex accountability system is functioning well for Pantex's needs. LLNL is evaluating LANMAS for reporting but has no plans to use it in the near future. LANL, the Y-12 Plant, and Sandia-New Mexico do not plan to use LANMAS. The Y-12 Plant has a fully integrated shop floor system that was recently replaced. LANL does not feel that LANMAS will support its needs, even though they were the original developers. Sandia-New Mexico has a functional system that does not require an extensive effort to support. DP funding continues to be made available for the development of systems with functions currently available in LANMAS.

The sites that use LANMAS indicate that it has fallen short in several areas, such as handling tamper-indicating devices (TIDs), radioactive decay, and error checking. For example, several sites had to devote substantial amounts of programming effort to develop their own TID modules because the LANMAS TID module did not meet their needs. In addition, although LANMAS provides for multi-user, real-time capability, this capability is either underutilized or has not been implemented by the users. All the sites that have implemented LANMAS opted for a paper-trail system with data entered at a central location; terminals are generally not located in material access areas where the actual movements of nuclear material take place. Conversely, the five major sites that do not use LANMAS have real-time, on-line data entry systems that are capable of promptly detecting a loss or error.

**LANMAS features and management are concerns at some sites.**

All sites indicated that the migration from old, legacy systems to LANMAS was costly in terms of time and level of effort, and all underestimated the needed level of effort and encountered unexpected problems during the migration. In addition, several sites expressed concerns about overall DOE program management and communications between LANMAS staff and the field. For example, some sites objected to the process for determining priorities for modifications to LANMAS because the process allows non-users to vote even if they do not fully understand the issues.

Another concern is that LANMAS is not fully compatible with IAEA reporting. For example, LANMAS cannot present the physical inventory list and the inventory change report in the format required by IAEA. This incompatibility creates problems for two sites (Rocky Flats and Hanford), which now maintain two sets of accounting records. Although compatibility with IAEA reporting is very important for DOE as a whole, only two LANMAS users are affected and those two sites were not able to gather the votes to make LANMAS/IAEA compatibility a priority. According to SO, development of an IAEA reporting module in LANMAS is one of many high-priority proposed software enhancements that DOE Headquarters, the LANMAS development team, and sites continue to examine and prioritize on a routine basis. Software to support this function is targeted for mid-June 2001. The existence of two sets of accounting records could cause misunderstandings between DOE and the IAEA.

**Some sites expressed concerns about delays in the issuance of NMMSS reports and compatibility with LANMAS.**

Users also expressed some concerns about NMSSS reporting and program management. Several facilities have been frustrated by excessive delay times for the receipt of month-end closing reports. For example, June 2000 reports were not available until August 25, 2000, and August 2000 reports were not available as of October 20, 2000. SO has not intervened to remedy this situation. In addition, NMMSS error rates have been excessive at several sites, reflecting frequent and recurring administrative errors such as incorrect project numbers. SO has distributed two memoranda to DOE sites indicating the need to reduce NMMSS error rates. Currently, 70 percent of the facilities have met the current SO objective of 2 percent or fewer errors in NMMSS reporting. Without effective

corrective action, timeliness and credibility of reporting will continue to be a concern.

The most frequent complaint involves the compatibility of NMMSS and LANMAS. DOE has made a decision to maintain separate systems. Routine meetings between staff of NMMSS and LANMAS are being held to ensure that systems are compatible, and SO has stated a very clear vision for LANMAS/NMMSS compatibility. The developers of NMMSS and LANMAS have discussed the differences and interfaces, and about half of the LANMAS programmers' effort has been devoted to achieving compatibility with NMMSS. However, incompatibilities are known and will remain for some time.

**Continual management involvement is necessary to ensure the long-term success of NMMSS and LANMAS.**

Overall, NMMSS and LANMAS are functioning, and LANMAS has met a DOE-wide need. While some aspects of the systems require further development, the current deficiencies do not significantly degrade the effectiveness of safeguards programs. Rather, the deficiencies in the two systems and the interface between the two are sources of frustration for the users, leading to duplication of effort and unnecessary inefficiencies in accounting, reconciliation, and reporting. While progress is being made and upgrades are continuing, efforts to ensure compatibility have not yet been successful. Further, LANMAS has not been accepted by several important DOE sites, and there is no indication that it will become the single, DOE-wide system in the foreseeable future. Additional attention and strong program management direction for both systems and the interface between the two systems could help alleviate these inefficiencies.

The current direction by DOE is to maintain two independent systems, and the two sets of developers retain autonomy. Several field MC&A personnel indicated that there are potential benefits to combining the two systems into a single unified system that performs both facility-level functions and national-level functions. However, DOE has not performed a comprehensive analysis of the potential for combining the two systems or a long-term needs analysis for the two systems. As of November 1999, both systems are under SO's management, whereas previously they were under different management structures. This organizational alignment presents an opportunity to improve program management and ensure consistency between LANMAS and NMMSS. In addition, NMMSS is undergoing a major upgrade and is currently in the requirement-definition stage—a good opportunity to take positive action to ensure compatibility.

# 3.0 Conclusions and Recommended Enhancements

The overall conclusion of this follow-up special study is that MC&A programs have improved substantially in the past few years at most DOE sites, but increased management attention is needed in some specific areas. The most immediate concerns involve the MC&A program at the Y-12 Plant and the methods for measuring foreign fuel returns. Although a less immediate safeguards concern, policy enhancements and improvements in the national and facility-specific accounting systems can improve the effectiveness of DOE MC&A programs while facilitating more efficient use of limited safeguards and security resources.

Volume 2 of this report includes specific recommendations that apply to each of the four focus areas evaluated in this follow-up special study. Independent Oversight has shared preliminary versions of these recommendations with SO, selected DP and EM personnel, and selected field MC&A personnel to gain their perspectives. The preliminary recommendations were generally well received, and the review resulted in some modifications; there is considerable debate within the MC&A community on issues such as measuring irradiated fuel.

This section summarizes, collates, and builds upon the specific recommendations from Volume 2 to identify three broad recommendations. The rationale for each of the three broad recommendations is discussed, and specific actions are presented for consideration by SO and line management.

The three recommendations are presented in order of safeguards priority. The first recommendation, dealing with the need for a clear policy for measurement of irradiated fuel, should be viewed as a high-priority, near-term need because of the large quantities of fuel being returned from foreign countries. A clear and comprehensive policy is needed to ensure that the U.S. has adequate assurance that fuel has not been diverted and that the risks associated with various measurement strategies (including the risks of not measuring materials) are clearly communicated, understood, and accepted by the responsible decision makers. The second recommendation relates to the need to reanalyze MC&A policy with the goals of strengthening some provisions and relaxing other provisions, providing for increased effectiveness of MC&A programs and, in the long term, providing for more efficient MC&A programs and cleanup efforts. The third recommendation, dealing with the compatibility of national and facility-specific accounting systems, should be given timely consideration because improvements in this area can enhance the usefulness of these systems, avoid duplication of effort, and increase the efficiency of MC&A functions—resulting in a net cost savings.

The recommendations in this section are **not** intended to address the Y-12 Plant findings or other site-specific inspection findings that are already being addressed through corrective action plans. The National Nuclear Security Administration, SO, DP, and Oak Ridge Operations Office management are aware of the problems at the Y-12 Plant and are working to develop a consensus resolution. Rather than duplicating previous findings, the recommendations in this report are targeted toward DOE as a whole, with emphasis on improving DOE policy.

**RECOMMENDATION #1. Establish a comprehensive policy and risk acceptance process for irradiated nuclear fuels.**

In light of the longstanding inability to develop and issue clear policy related to irradiated nuclear fuel and the increased foreign fuel returns to DOE, increased senior DOE management attention is needed to ensure that DOE Headquarters enhances policy to explicitly address MC&A requirements for irradiated nuclear fuel. While important efforts continue to solicit field input and develop consensus approaches, further delays are not prudent. Headquarters decisions and direction are needed to establish a policy and to direct the field and R&D efforts to a common goal. To this end, the following aspects of an enhanced policy base should be considered:

- DOE should establish a clear policy that considers the safeguards risks, costs, and operational impacts of measuring irradiated nuclear fuel. The policy should provide for consistently effective protection across DOE sites and should examine the life cycle of irradiated nuclear fuel to identify points where safeguards actions (including measurements) are required. Provisions should identify required actions (such as a measurement at a feasible time) when data on measured values of irradiated nuclear fuel are unavailable or unreliable (e.g., records dating back 30 years are incomplete or lost), when positive identification is not possible (e.g., unreadable or missing serial numbers), and when integrity of items has been lost (e.g., broken pieces and corrosion resulting in sludge). Provisions should be established for conducting measurements or performing a vulnerability assessment in certain circumstances (e.g., when there has been a period of time where the items were not self-protecting or not stored in a tamper-indicating configuration). Section B of Volume 2 provides preliminary attempts to develop decision tools that could provide a starting point for certain aspects of policy development.

- The policy should explicitly address foreign returns and provide for a higher level of protection because of the increased potential for diversion. The policy should also require a valid measurement of all irradiated nuclear fuel. If statistical sampling is permitted, the sampling method should be based on a technically valid sample that provides high assurance that a diversion of a significant number of fuel rods would be detected. The policy should include a clear provision for making the measurements as soon as possible after receipt or possession by DOE and identify action to take if a discrepancy is discovered. If timely measurements are not possible because of the volume of returns or lack of equipment, there should be a clear requirement for DOE Headquarters approval. DOE should not rely on continuity of knowledge unless there is a clear and explicit risk acceptance by senior DOE management and concurrence by other appropriate government agencies (e.g., Department of State, Central Intelligence Agency).

- DOE Headquarters should accelerate and coordinate R&D efforts to ensure that DOE priorities are addressed and that equipment is developed to meet current and expected needs.

- DOE should reexamine its plans for ultimate disposition of irradiated nuclear fuel to identify and incorporate MC&A provisions (where feasible and effective), including provisions for measurements prior to permanent storage and integration of MC&A considerations into packaging strategies.

**RECOMMENDATION #2. Reevaluate DOE policies to strengthen certain requirements to enhance the effectiveness of MC&A programs.**

SO should conduct a careful analysis of the safeguards benefits, costs, cost savings, and worker safety implications of a number of potential enhancements to DOE orders. The analysis should include the life cycle of materials, such as scrap, to ensure that all costs and benefits are considered. Specifically:

- Establish requirements for prompt loss detection and modify other requirements accordingly (reduce frequency of process inventories).

- Establish a comprehensive scrap control program with requirements for timely processing of scrap that cannot be adequately measured.

- Eliminate the requirement for physical inventory confirmation measurements so that measurement resources can be reallocated to verification measurements.

- Require verification measurement of all non-tamper-indicating items at the time of the physical inventory (eliminate the current option for statistical sampling items).

- Adopt NRC MC&A definitions where DOE does not currently provide a definition, and include the definitions in a DOE order.

- Implement a requirement for item monitoring that provides a quantitative loss detection program with specified goals for power of detection and timeliness.

- Establish measures to identify human errors as a special category and monitor and control human error rates.

- Require a periodic estimation of error variances for bulk measurement systems and sampling techniques.

- Establish a firm policy on bias correction that is comparable to current NRC regulations.

- Require reconciliation of physical inventories within a specified time (e.g., 45 calendar days).

- Establish a clear policy for MC&A records retention.

In the longer term, DOE should reassess its approach to MC&A orders to include development of: (1) an MC&A order with clear performance objectives; (2) a format and content guide for MC&A plans; (3) acceptance criteria to assist DOE in evaluating contractors' MC&A plans; and (4) a defined MC&A plan approval process. Such an effort was initiated in the past but has never been completed. DOE should establish a clear schedule with milestones for reassessing its approach and, if appropriate, developing a revised approach that is institutionalized in a revised DOE order.

**RECOMMENDATION #3. LANMAS and NMMSS have improved MC&A reporting in the DOE complex during the past 12 months, and increased management attention is essential to ensure long-term success.**

The recent change in management structure that gives SO responsibility for directing both LANMAS and NMMSS development efforts, in combination with the ongoing effort to upgrade NMMSS, provides a unique opportunity to enhance management and coordination. The following actions should be considered as methods to improve coordination, reduce duplication of effort, and enhance communications between developers and users:

- SO, in coordination with DP (which manages the sites that are not using LANMAS), needs to determine whether the benefits of making LANMAS the single, DOE-wide accountability system outweigh the costs and operational impacts of converting the remaining DOE sites that do not use LANMAS. If so, SO and DP need to develop a long-term plan for ensuring that the remaining sites migrate to LANMAS, which will entail some conversion costs and resistance from some sites.

- LANMAS development, currently funded as an R&D program, should transition to a permanent operational activity program funded as part of the DOE operations budget. Although modifications are still being made, LANMAS is in full operation at nine DOE sites, and the changes are no longer characterized as R&D efforts. The LANMAS program should be managed as an operational system with strict configuration controls and a clear program plan to ensure that the standardization effort is not degraded by the existence of different versions of the LANMAS software. (There is some indication that this is already beginning to happen.)

- SO should strengthen and enhance LANMAS and NMMSS to address compatibility issues in the near term and long term. In the near term, SO should establish a plan that provides for compatibility between NMMSS and LANMAS and ensures that both sets of developers understand and adhere to the plan. SO needs to be an effective and timely arbiter when disputes arise. SO-23 management has stated a very clear vision for LANMAS that the information transferred to NMMSS should be compatible. Staffs meet regularly and are being encouraged to adopt this vision of compatibility. This effort should include an assessment of the benefits (e.g., efficiencies associated with eliminating compatibility concerns and duplication of effort on similar modules) and obstacles (e.g., transition costs for DOE and NRC facilities) of combining the NMMSS and LANMAS programs into a single, comprehensive program for both national and facility-specific needs.

- SO should take actions to enhance communications between the developers and users of LANMAS and NMMSS, including the use of e-mail and Web pages to facilitate communication and customer quality surveys.

- SO should continue their efforts to coordinate software upgrades, including regularly issuing an memorandum that defines planned upgrades, to allow sites to better plan for the associated costs.

- While still emphasizing the importance of priorities voted on by the user group configuration management board, SO should exercise leadership in ensuring that LANMAS development is responsive to overall DOE objectives, such as IAEA compatibility, and not just to the majority votes of the user group, which does not represent all DOE priorities and views.

# APPENDIX A
# TEAM COMPOSITION

The team membership, composition, and responsibilities were as follows:

## Office of Independent Oversight and Performance Assurance

Glenn Podonsky, Director
Michael Kilpatrick, Deputy

## Office of Safeguards and Security Evaluations

Barbara Stone, Director
John Hyndman, Deputy

## Independent Oversight Review Team

Peter Rodrik, Team Leader
William Kilmartin
D. L. Whaley
Ken Byers
Vince DeVito
Gary Kodman
Ron Hawkins
Tom Davis

## Office of Security and Emergency Operations Representatives

Kelly Coady
Lynne Preston

## Office of Environmental Management Representative

Leigh Gunn

## Quality Review Board

Michael Kilpatrick
Barbara Stone
John Hyndman
Dean Hickman

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