

DOE/IG-0560

AUDIT  
REPORT

THE DEPARTMENT OF ENERGY'S  
TRITIUM EXTRACTION FACILITY



JUNE 2002

U.S. DEPARTMENT OF ENERGY  
OFFICE OF INSPECTOR GENERAL  
OFFICE OF AUDIT SERVICES



U. S. DEPARTMENT OF ENERGY  
Washington, DC 20585

June 24, 2002

MEMORANDUM FOR THE ADMINISTRATOR, NATIONAL NUCLEAR SECURITY  
ADMINISTRATION

FROM: Gregory H. Friedman (Signed)  
Inspector General

SUBJECT: INFORMATION: Audit Report on "The Department of Energy's  
Tritium Extraction Facility"

BACKGROUND

On March 19, 2002, you asked the Office of Inspector General to conduct an expedited review of efforts to construct the Tritium Extraction Facility (TEF) at the Department of Energy's Savannah River Site. Specifically, you expressed concerns about information you had received indicating that the TEF may be over budget and behind schedule.

The Department is in the process of constructing the TEF at Savannah River as part of a process to ensure that the United States has an adequate supply of tritium, a radioactive isotope of hydrogen used in all of the Nation's nuclear weapons. When fully operational, the TEF will provide the capability to extract gases containing tritium as part of the Commercial Light Water Reactor Program. The current baseline for the project, established in 1999, provided that the TEF was to be completed by February 2006 at a cost of \$401 million, and that it was to produce 3 kilograms of tritium per year. The National Nuclear Security Administration (NNSA) is responsible for the overall management of the TEF Project and an integrated team of Westinghouse Savannah River Company and Bechtel Savannah River, Inc. personnel carries out day-to-day construction management activities.

Consistent with your request, the objective of our audit was to determine whether the TEF Project was within cost, schedule, and technical scope.

RESULTS OF AUDIT

We found that the TEF will cost substantially more than the planned \$401 million. Further, based on current progress, it is unlikely that the facility will be completed by February 2006. In fact, key project management officials have estimated that the total project cost could increase to as much as \$500 million, that the facility may not be completed until December 2006, and that, under certain scenarios, it may not contain all elements of the original specifications. Completion of the TEF within its baseline cost, schedule, and scope was in jeopardy because the project team had not made full use of available project management controls. Specifically, it had not:

- completed project design before beginning construction;
- conducted make/buy analyses at key points;
- chosen a contract vehicle appropriate for the nature of the project;
- established adequate contingency funds;
- adequately updated project risk assessments and cost estimates to reflect changing conditions; and,
- included the TEF on its "Watch List" of projects requiring heightened scrutiny.

As a consequence, the TEF lacks a viable baseline and NNSA cannot be assured that the facility will be available when needed or that project funds are being expended efficiently. Delays in completion of the TEF Project also have the potential to impede performance of the Stockpile Stewardship Program.

In recent months, management initiated reviews attempting to validate the Westinghouse team's estimated overages and the potential savings of alternative strategies. In each instance, the reviewers were unable to do so and cited a lack of adequate supporting documentation. Until this condition is remedied, NNSA cannot be assured that the cost and schedule issues raised by the project team are valid. At some point, the process will likely drive a request to Congress for additional funds. Thus, reaching agreement on the path forward, and the costs associated with the selected strategy, takes on great importance.

You also asked us to assess, during our review, the relative culpability of those responsible for the current conditions. Available documentation, as well as interviews with key Federal and contractor officials, disclosed that the decisions made and the strategies pursued were the product of the collective judgments of the Federal and contractor project team leaders. As a consequence, we concluded that accountability must be shared. We found that there was an especially close working relationship between cognizant Federal and contractor officials. Although we could not conclude that this relationship was a root cause for the conditions that exist, NNSA management, as part of an overall path forward strategy, should nevertheless review the current management structure in order to determine whether changes are warranted.

Our findings in regard to the TEF are consistent with those of a 1999 National Research Council review of the Department's project management practices. That review highlighted many recurring problems with the Department's approach to major projects. The Council noted, for example, that (1) pre-construction planning was often inadequate and ineffective and (2) project baselines were established too early in the design stage to be reliable. The Council report also cited the tendency to establish contingencies that were unrealistically low because they did not adequately take into account project risks. Additional Council findings also included ineffective matching of project requirements and contracting methods.

Based on our audit we recommended a series of specific actions aimed at strengthening the TEF Project. We also made recommendations that have broader applicability in your efforts to enhance and revitalize the nuclear weapons program.

MANAGEMENT REACTION

Your memorandum dated June 12, 2002, (see Appendix 1) indicated concurrence with our recommendations. The Office of Inspector General appreciated the cooperation of NNSA staff and senior management through this expedited review.

Attachments

cc: The Secretary  
Chief of Staff  
Under Secretary for Energy, Science and Environment  
Deputy Administrator for Defense Programs  
Manager, Savannah River Operations Office  
Director, Policy and Internal Control Management, NA-66

# THE DEPARTMENT OF ENERGY'S TRITIUM EXTRACTION FACILITY

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## TABLE OF CONTENTS

### Overview

Introduction and Objective.....	1
Conclusions and Observations.....	1

### Status of Tritium Extraction Facility

Details of Finding.....	3
Recommendations and Comments .....	9

### Appendices

Management Comments .....	11
Scope and Methodology.....	12
Other Matters.....	13

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## Overview

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### **INTRODUCTION AND OBJECTIVE**

On March 19, 2002, the Administrator of the National Nuclear Security Administration (NNSA) asked the Office of Inspector General to review NNSA's efforts to construct the Tritium Extraction Facility (TEF) at the Department of Energy's (Department) Savannah River Site. Specifically, the Administrator expressed concerns about information he had received indicating that the TEF may be over budget and behind schedule.

Tritium is a radioactive isotope of hydrogen used in all of the Nation's nuclear weapons. Without tritium, these nuclear weapons will not work as designed. Tritium has not been produced for the United States nuclear weapons stockpile since 1988. Radioactive decay also depletes the available tritium by about 5.5 percent each year. Current stockpile requirements are being met by recovering tritium from dismantled nuclear weapons. However, the amount of tritium available may not be adequate to meet long-term national security requirements. In order to meet long-term tritium requirements, the TEF is being constructed at Savannah River, as part of the Commercial Light Water Reactor Program.

NNSA Headquarters is responsible for the overall management of the TEF Project. The NNSA manager at Savannah River provides infrastructure support to the project. The Manager, Savannah River Operations Office provides health, safety, and technical support to the project on an as needed basis. An integrated team of Westinghouse Savannah River Company and Bechtel Savannah River, Inc. (Westinghouse team) personnel carries out day-to-day construction management activities.

The objective of the audit was to determine whether the TEF Project was within cost, schedule, and technical scope.

### **CONCLUSIONS AND OBSERVATIONS**

Key project management officials have estimated that the total project cost for the TEF could increase to as much as \$500 million, and that the facility may not be completed until December 2006. They had also considered certain reductions in scope. In our judgment, NNSA had not made full use of available project management controls. As a result, management lacks assurance that the facility will be available when needed or that project funds are being expended efficiently. Delays in completion of the TEF Project also have the potential to impede performance of the Stockpile Stewardship Program.

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For many years, the Office of Inspector General has reported on project management weaknesses at the Department and NNSA. Since the early 1990s, we have issued a series of reports critical of the planning, justification, and management of major projects. Based on our findings, we have reported to the Secretary that project management is one of the most significant management challenges the Department and NNSA face.

The TEF Project has been the subject of numerous internal and external reviews since its inception in 1996. At least four of these reviews were completed in early 2002 after key TEF project management officials identified significant cost and schedule concerns in November 2001. Moreover, during our audit, we learned that an additional review effort had been initiated by NNSA. Specifically, it is our understanding that a senior Federal project management official will validate a new estimate at completion. Accordingly, a number of key "path forward" decisions will be made using the results of the additional review effort, slated for completion by the end of July 2002.

Our audit identified issues that management should consider when preparing its yearend assurance memorandum on internal controls.

(Signed)  
Office of Inspector General

## Status of Tritium Extraction Facility

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### TEF Cost, Schedule, and Technical Scope

At the time of our review, project management officials from NNSA and the Westinghouse team had concluded that the TEF was in jeopardy of significantly overrunning its baseline cost, perhaps by nearly \$100 million, or 25 percent. The first indications of cost concerns were reported in March 2001, but it was not until November 2001 that the extent of the problem was thought to be of major significance by the Westinghouse team. By February 2002, achievement of the baseline schedule was clearly in doubt, and alternative scenarios were developed under which the TEF would not be capable of meeting its planned mission of extracting tritium necessary for long term national security requirements.

### Acquisition Strategy

The acquisition strategy for the TEF consists of two major phases. The first phase included issuance, in 2000, of a competitive fixed-price construction/structural/architectural subcontract for design and the construction of two building shells. The second phase, scheduled to begin in 2002, provides for construction and testing of the "rest of plant." In January 2002, the Westinghouse team informed NNSA management that, under the current strategy, project costs were likely to approach \$500 million and the schedule would be extended until at least December 2006. Examples of contributing factors to actual or potential cost overruns cited by the Westinghouse team included the following:

- \$17 million for modifications required to overcome various unforeseen construction issues;
- \$12 million in unanticipated costs associated with the decision to accelerate phase one design and construction;
- \$7 million for a furnace design that ultimately did not work;
- \$7 million for adjustments to wages and overhead costs;
- \$5 million for higher-than-expected costs for equipment; and,
- \$21 million in potential costs associated with extending the schedule to December 2006.

As we will discuss later in this report, we are troubled by the fact that a number of efforts to review and validate these numbers have been unsuccessful due to perceived deficiencies in contractor documentation.



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NNSA managers had also concluded that the TEF would likely cost substantially more than the \$401 million baseline estimate. A number of these officials acknowledged that the baseline had not been sufficiently adjusted to reflect costs associated with a Congressional hold on construction funds. Some officials believed that this may have added at least \$30 million to total project costs. Management was also concerned about the subcontract bids for the phase two "rest of plant" portion of the TEF Project, as they were substantially higher than the amount originally estimated for this work.

#### Alternative Strategies

In light of the potential for significant cost overruns, the Westinghouse team proposed a new strategy, by which Westinghouse and Bechtel would self perform significant remaining work in-house, rather than perform the work via subcontract. Under this option, firm-fixed-price subcontracts would be issued for the fabrication of standard items, such as heating and air conditioning systems, fire protection, satellite buildings and structural steel. Westinghouse & Bechtel would self-perform higher risk fabrication items such as glove-box internals and piping equipment. The Westinghouse team estimated that this option would reduce the cost overrun from about \$100 million to about \$80 million and extend the project completion date from February 2006 to October 2006.

A variation of this strategy would further decrease the potential cost overrun but possibly extend the project completion date to July 2007 and reduce scope. This option included the elimination of the waste storage building, storage module, robotic platform, and installation of the second furnace. These scope reductions would, according to the Westinghouse team, make it unlikely that the TEF could produce the planned 3 kilograms of tritium per year. As of April 2002, NNSA management had approved this alternative in principle; however, no final decision on approach had been made.

We did not attempt to validate the Westinghouse team's proposed alternatives and, accordingly, take no position as to which, if either, represents a prudent approach to project completion. Based on a limited review of some of the associated estimates, however, we concluded that, at least in one instance, an alternative merely shifted costs from one category to another and did not actually reduce the amount of funds required.

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We were also aware that in recent months management initiated reviews attempting to validate the Westinghouse team's estimated overages and the potential savings of the proposed alternative strategies. In each instance, the reviewers have been unable to do so and have cited a lack of supporting documentation by the Westinghouse team. Until this condition is remedied, the NNSA cannot be assured that the cost and schedule concerns expressed by the Westinghouse team are valid and are as substantial as asserted. In this vein, NNSA instructed the Westinghouse team to complete the necessary documentation and planned, yet again, to attempt to validate the estimate by the end of July 2002.

**Stockpile Stewardship  
Plan and Project  
Execution Plan**

The Department's (unclassified) Stockpile Stewardship Plan (Plan) establishes the mission requirement for tritium and delineates the approach to meeting the Nation's tritium needs via the TEF. The Plan specifies that the expected need for tritium will be about 2.5 kilograms per year and that, if the TEF is complete and operational by 2006, mission requirements will be met.

Department requirements specify that a Project Execution Plan should be prepared to define the specific requirements that form the project baseline. The TEF Project Execution Plan was established in June 1997 and specified that a facility capable of producing about 3 kilograms of tritium per year would be constructed for a total project cost of \$384 million, with operations starting in May 2005. In 1999, the completion date was extended to February 2006, and in March 2001, the total project cost was increased to \$401 million.

**Project Management  
Controls**

Federal and contractor project team members indicated that a number of factors contributed to cost and schedule overruns, many of which were beyond the project team's control. Among these were changes in the regulatory environment, especially with respect to safety, security, and transportation. While we recognize the potential impact of these factors, we concluded that the TEF baseline cost, schedule, and scope was in jeopardy primarily because the NNSA had not made full use of available project management controls. We noted, in particular, that it had not completed project design before beginning construction or conducted make/buy analyses at key points. In addition, the federal and contractor project team leadership chose a contract vehicle that may not have been appropriate for the nature of the project. Other contributing factors included an inadequate contingency fund, risk assessments and cost estimates that were not adequately updated to reflect changing conditions, and failing to list the TEF on the "Watch List" of projects requiring heightened scrutiny.

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### Project Design

As originally conceived, the final design of the TEF was to be completed and reviewed before construction of the facility was to begin. However, in 1999, following a one-year hold on project construction funds, the Department and the Westinghouse team attempted to make up for lost time by adopting a two-phased simultaneous "design-build" approach to the acquisition strategy. As a consequence, the subcontractor was allowed to begin construction before final design was complete. According to project team managers, as well as other project reviewers with whom we spoke, this resulted in adverse effects on the project's cost and schedule due to numerous design changes. The Westinghouse team estimates that at least \$12 million in project overruns can be directly attributed to the revised approach.

### Make/Buy Analyses

The Department's acquisition regulation requires that outsourcing opportunities be evaluated to determine whether they should be performed by the management and operating contractor in-house (make) or outsourced (buy). This requirement is also included in the contract with Westinghouse. Nevertheless, key acquisition points in the TEF Project were not supported by formal make/buy analyses. This included the initial strategy of using a single subcontractor to complete the project, as well as the subsequent decision to change the acquisition so that some work would be performed in-house and the rest via subcontract. These decisions were based on discussions of expediency and cost-effectiveness, and reliance on cost data that was available at the time. In essence, the project team made assumptions that a given acquisition strategy would save time and money, but did not perform a formal make or buy analysis.

### Contract Type

Acquisition principles suggest that for a well-defined scope of work with relatively few unknowns, a firm-fixed-price contract may be a prudent acquisition vehicle in that the contractor assumes a relatively greater share of financial risk. The choice of a firm-fixed-price contract can become problematic, however, when the scope of work is less well defined. In such a scenario, unanticipated changes not explicitly defined in the original contract can drive up total costs. This appears to have been the case with the TEF Project, which has

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included many changes and modifications to date. At least one Westinghouse official also suggested that the unexpectedly high bids for phase two of the project arose, at least in part, because of bidders' perceptions that the TEF Project is still subject to many technical uncertainties at the same time that firm-fixed-price contracts are being employed.

### Contingency Funds

Contingency funds are established to cover costs that may result from incomplete design, unforeseen circumstances, or uncertainties within defined project scope. Departmental guidelines state that for facilities that include complex design and equipment, contingency should be established in the range of 20 to 30 percent of costs to be incurred. While a contingency fund does not, by itself, keep costs down, it can serve as a key control to help management to protect the integrity of the overall cost baseline while still responding to unexpected events. Moreover, a closely monitored contingency serves as an early warning system to project managers if the use of contingency funds exceeds expectations. For the TEF, contingency was established at about \$65 million, or 16 percent of the expected total project costs.

As of November 2001, the entire \$65 million had been allocated to cover such events as unforeseen construction issues, the furnace design that did not work, and the higher-than-expected costs for equipment. Two key Federal project officials also indicated that an artificially low contingency was another consequence of a management imperative to keep total project costs at about \$400 million.

### Updated Estimates and Risk Assessments

Indeed, Department and contractor officials also advised us that senior management direction focused on total project costs rather than project requirements. They reported that then senior Department leadership directed, at least informally, that the TEF's total project cost not exceed \$400 million. As a consequence, a number of project managers felt constrained by this cost ceiling and did not update risk assessments and project estimates to adequately reflect changing conditions. In our opinion, this is unacceptable. To the extent that responsible project officials believed that senior management direction was inconsistent with sound project practices, these officials had a duty to raise these concerns at that time.

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Although the Department increased the total project costs by \$12 million to compensate for the effects of the funding delay, two Federal project managers told us that the true costs of the delay were probably at least \$30 million. These officials acknowledged that they should have been more assertive in highlighting the cost and schedule risks associated with this major change in circumstances. Instead, project officials tried to absorb the schedule slip and cost escalation, in order to keep the costs below \$400 million.

We also noted that the contractor did not perform an estimate at completion<sup>1</sup> on an annual basis. Although Federal and contractor procedures did not specifically require an estimate at completion to be prepared annually, according to the American National Standards Institute, this is an industry best practice for construction projects. A key contractor official also stated that frequently prepared estimates at completion help to capture issues and problems that may not be identified elsewhere. We noted that in February 2002, Westinghouse amended its Project Controls Manual to require preparation of an annual estimate at completion when the project exceeds \$4 million. A project management official also told us that Westinghouse intends to include an updated estimate at completion in each of its monthly status reports for the remainder of the TEF Project.

Although the Department sent independent cost estimating teams to review the TEF in 1997, 1998, and 1999, a senior Department project management official told us that there are a number of problems with the independent cost estimating teams as currently configured. First, the reviews typically last only 1 to 2 weeks, which may not be enough time, in all cases, to thoroughly review estimates. Also, review teams do not generally perform their own "bottoms up" review, but rather validate a sample of the documentation used by the contractor to develop the estimates. This official cited the need for a comprehensive approach to cost validation on the TEF Project.

#### "Watch List"

Federal and contractor project management officials told us that senior Department managers did not attend a number of quarterly status briefings on the TEF held for their benefit. Our review also disclosed that the TEF Project was not included on the Department's "Watch List"

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<sup>1</sup>An estimate at completion is defined as the actual cost incurred to date (including accruals) plus the estimated cost for completing the work.

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of projects requiring heightened scrutiny. Despite information available to management in November 2001 that qualified the TEF for inclusion on the "Watch List," it was not included. While listing the TEF on the "Watch List" at that late date would not likely have prevented cost and schedule overruns, including it on the list now may serve as an additional project management control to ensure senior management attention.

## **TEF and Stockpile Stewardship**

Given the significant uncertainties facing the project and the absence of a viable baseline for cost, schedule, and technical scope, NNSA lacks assurance that the TEF will be available when needed and that project funds are being expended efficiently. Delays in completion of the TEF project also have the potential to impede performance of the Stockpile Stewardship Program.

As specified in the Stockpile Stewardship Plan (Plan), tritium is needed by approximately 2006 to support the current requirements for the nuclear weapons stockpile. The Plan calls for new tritium in inventory and a reliable production source for future needs. Because the TEF is the only current option NNSA has for extracting and processing new tritium, its timely completion is of critical importance.

The Office of Inspector General previously identified the Stockpile Stewardship Program as one of the top 10 management challenges facing the Department and the NNSA. In our judgment, these previously reported issues, taken together with the project management concerns jeopardizing prompt completion of the TEF, highlight the urgency with which NNSA must address overall performance issues within the Stockpile Stewardship Program.

## **RECOMMENDATIONS**

To ensure that NNSA's project management practices are improved for future projects, we recommend that the Administrator, NNSA review and amend NNSA policies and procedures to require that project managers:

1. Complete final design before awarding construction contracts, particularly firm-fixed-price contracts involving first-of-a-kind nuclear facilities.
2. Ensure project direction promotes the creation of an appropriate balance between cost control and mission essential project requirements.

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3. Update risk assessments and estimates at completion at least annually throughout the life of the project.
  4. Implement a more comprehensive approach to independent cost estimating.

To facilitate prompt and effective completion of the TEF, we recommend that the Administrator, NNSA:

5. Insist that the Westinghouse team produce, by no later than July 2002, sufficient supporting documentation for its current estimates for projected overruns and for the cost and schedule of alternative approaches to project completion.
6. Prepare a revised project baseline including cost, schedule, and technical scope.
7. Ensure that all future acquisition approaches to the TEF are supported by properly documented make/buy analyses.
8. Award firm-fixed-price subcontracts only for components of the TEF Project known to involve low technical risks.
9. Re-evaluate the adequacy of available contingency funds and adjust as necessary.
10. Add the TEF Project to the "Watch List" and ensure that it stays on the list until all issues are adequately resolved.

# Appendix 1

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**Department of Energy**  
**National Nuclear Security Administration**  
Washington, DC 20585  
JUN 12 2002

OFFICE OF THE ADMINISTRATOR

MEMORANDUM FOR Gregory H. Friedman  
Inspector General

FROM: John Gordon  
Administrator

SUBJECT: Draft Report on the Tritium Extraction Facility

On March 19, 2002, I requested that your staff conduct an expedited audit of the Tritium Extraction Facility under construction at the Savannah River Site to address my concerns that the project may be over budget and behind schedule. I have been briefed on your findings, and I believe they validate our views about shortcomings in the execution and management of the project.

As soon as I was apprised of potential problems with the Tritium Extraction Facility, I dispatched a team of senior managers to Savannah River to assess the project and recommend an approach to get the facility back on track. I concur with your recommendations and I have directed the management team to incorporate your recommendations into their plan of action.

I appreciate your cooperation in responding to my request in such a short amount of time. Any technical comments on the draft report will be submitted separately. After your final report is issued I will submit a comprehensive management decision to ensure that your recommendations are applied at the Tritium Extraction Facility and in the execution of other construction projects.

cc: Deputy Administrator for Defense Programs, NA-10  
Assistant Deputy Administrator for Military Application  
and Stockpile Operations, NA-11  
Associate Administrator for Management and Administration, NA-60



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## Appendix 2

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### SCOPE

The audit was performed from March 26, 2002, to April 30, 2002, at Department Headquarters and the Savannah River Operations Office. The scope of the audit included TEF project management activities from December 1995 through April 2002.

### METHODOLOGY

To accomplish the audit objective, we:

- Reviewed results of prior audits and reviews;
- Identified the TEF Project technical scope, cost, and scheduled milestones;
- Analyzed the status of the project and the contractors' performance;
- Assessed the appropriateness of the contracting strategy;
- Discussed project management activities with Department and contractor personnel; and,
- Reviewed Department regulations and contractor procedures governing project management.

The audit was performed in accordance with generally accepted Government auditing standards for performance audits and included tests of internal controls and compliance with laws and regulations to the extent necessary to satisfy the audit objective. Accordingly, the assessment included reviews of TEF Project management activities. Because our review was limited, it would not necessarily have disclosed all internal control deficiencies that may have existed at the time of our audit. We did not conduct a reliability assessment of computer-processed data because only a very limited amount of computer-processed data was used during the audit.

In accordance with the Government Performance and Results Act of 1993, the Department has established performance measures for its Management and Operating contractor, Westinghouse Savannah River Company, related to the Tritium Extraction Facility. The measures are related to completing construction activities and commencing startup testing.

We held an exit conference with NNSA on May 7, 2002.

## **Appendix 3**

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### **OTHER MATTERS**

As a result of some of the prior reviews, certain criticism has emerged with respect to the performance-based incentives (PBIs). Specifically, some have observed that the existing incentives did not adequately encourage the contractor to improve upon dated events. Additionally, in the event the contractor missed a progress milestone, the contractor was allowed to "catch up" and ultimately receive a reduced fee. Further, the Department was criticized for not structuring the PBIs to ensure that the contractor shared the risk for potential cost overruns. Nevertheless, our review did not disclose that the PBIs, as structured, were a root cause for the cost and schedule conditions that now exist. In any event, as part of the Department's anticipated path forward strategy, it is our understanding that the PBIs will be renegotiated as appropriate.

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2. What additional information related to findings and recommendations could have been included in this report to assist management in implementing corrective actions?
3. What format, stylistic, or organizational changes might have made this report's overall message more clear to the reader?
4. What additional actions could the Office of Inspector General have taken on the issues discussed in this report which would have been helpful?

Please include your name and telephone number so that we may contact you should we have any questions about your comments.

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