4.0 PILOT PROGRAMS: QUALITY ASSURANCE AUDITS PERFORMED BY INDEPENDENT INSPECTORS

Section 13(c) of the Ford Amendment directs the NRC to conduct a pilot program to better assess the feasibility and benefits of implementing alternatives 13(b)(1) - 13(b)(5). In particular, Section 13(c) directed that alternative b(5), which proposes the use of third-party audits, be tested through a pilot program. The text of the pilot program requirement is as follows:

> Pilot Program
>
> ...the Commission shall undertake a pilot program to review and evaluate programs that include one or more of the alternative concepts identified in subsection (b) for the purposes of assessing the feasibility and benefits of their implementation. The pilot program shall include programs that use independent inspectors for auditing quality assurance responsibilities of the licensee for the construction of commercial nuclear power plants . . . .
>
> The pilot program shall include at least three sites at which commercial nuclear powerplants are under construction. The Commission shall select at least one site at which quality assurance and quality control programs have operated satisfactorily, and at least two sites with remedial programs underway at which major construction, quality assurance or quality control deficiencies (or any combination thereof) have been identified in the past.

Before conducting the pilot program, the NRC staff reviewed the feasibility of testing each of the alternative concepts in a pilot program, with the following conclusions

Alternative b(1): More prescriptive architectural and engineering (A&E) criteria.

Because reactor plants under construction are in advanced stages of construction, a pilot program for testing the feasibility and benefits of more prescriptive A&E criteria could not be implemented. However, the NRC staff did analyze this alternative (Chapter 6).

Alternative b(2): Conditioning the construction permit (CP) on the applicant's demonstration of its ability to independently manage a quality assurance (QA) program.

No CP applications are currently pending, so this concept could not be tested on a current CP applicant, nor could a current CP application be conditioned on this requirement. This study considered two types of demonstrations of QA management capability. The first is a pre-CP issuance assessment, which evaluates potential management capability prospectively. The second is a post-CP demonstration, which assesses management capability and QA program effectiveness based on a review of the implementation of the QA program over some previous period of time. Because there are no new CP applicants

currently, the pre-CP assessment could not be done as part of a pilot program. However, a post-CP test could be performed of this concept and was included as part of the pilot program.

Alternative b(3): Improved audits by associations of professionals.

The Institute of Nuclear Power Operations (INPO) has developed a new Construction Project Evaluation (CPE) Program, which represents a significant improvement in the capability of professional organizations to provide comprehensive evaluations of construction projects. To assess the new program's feasibility and benefits, senior NRC design and construction inspection staff monitored three INPO CPEs--Beaver Valley 2, Limerick, and Millstone 3. At these projects, INPO's methodology, and its depth and breadth were evaluated. Although NRC review of these INPO evaluations might be considered pilot programs, they are not treated as such in this report for two reasons: (1) the three plants covered do not meet the Ford Amendment pilot program criterion that at least two of the projects covered by the pilot have remedial programs under way, and (2) the CPE was past the pilot stage. INPO had tested an earlier version of their CPE program as a pilot in early 1982, and the industry had tested it later in 1982. The CPE program is now a routine INPO program, not a trial program. The role of INPO in the assurance of quality and NRC's analysis of the INPO CPE program are discussed in Chapter 5.

Alternative b(4): Improvements to NRC programs.

Several improvements to NRC's programs have been tested and implemented. Both the Construction Appraisal Team (CAT) and the Integrated Design Inspection (IDI) programs were fully implemented in June of 1983 after a pilot period that included several trial inspections. Chapter 7 discusses the CAT and IDI programs and several other improvements to the NRC program that were subject to trial periods before they were implemented, including the Resident Inspector Program and the Systematic Assessment of Licensee Performance (SALP) Program. Other future improvements to the NRC program suggested in Chapter 7, such as performance objectives for QA programs, will be subjected to a trial program before they are fully implemented. The case studies (see Chapter 3) also may be considered as a pilot for future NRC management assessments. However, for this study, the above activities are not treated as pilot programs in the sense of the Ford Amendment and are covered elsewhere in the report.

Alternative b(5): Conditioning the issuance of CPs for commercial nuclear power plants on the permittee entering into contracts or other arrangements with an independent auditor to audit the quality assurance program to verify quality assurance performance.

The Ford Amendment required that this alternative be tested as part of the pilot program. The Ford Amendment stipulated that at least two projects from the set consisting of Marble Hill, Midland, Zimmer, Diablo Canyon, and South Texas be selected for the pilot program, as well as at least one other project. These five projects were identified in the legislative history of the Ford Amendment as having had major quality-related problems.

In selecting sites for the pilot program, the NRC staff relied heavily on the legislative history of the Ford Amendment to try to be as fully responsive as possible to the intent of Congress. Statements made by sponsors of the Ford Amendment in introducing the amendment contributed heavily to developing the following general criteria for selecting sites for the pilot program:

(1) To the extent possible, sites will be selected that have qualifying programs already under way or that have in the past conducted such programs.

(2) To the extent possible, programs and sites will be selected to minimally disrupt ongoing construction activities.

(3) To the extent possible, sites will be selected whose owners will participate willingly in the pilot program. The legislative provision in Section 13 that allows the NRC to order participation would be used only if necessary.

(4) To the extent possible, sites will be selected with different architect/engineer (A/E), constructor, and project management arrangements. Testing the pilot programs with a variety of participants should better indicate an alternative's potential.

Based on these criteria and the Congressional guidance that at least two sites must come from the list of five plants mentioned earlier, NRC staff contacted four utilities and obtained agreement from each to participate in the pilot program. The projects selected for the pilot program test of the third-party audit alternative, and the third-party auditor that each selected, are as follows:

Project	Auditor
Palo Verde	Torrey Pines Technology
Marble Hill	Torrey Pines Technology
South Texas	Gilbert Commonwealth Associates
Midland	TERA Incorporated

Each utility that participated in the pilot program did so willingly. Moreover, the four selection criteria were met in almost every case. The only exception was that Marble Hill did not meet criterion (1). The utility, Public Service of Indiana, did not have a qualifying program under way and contracted for this special review specifically in response to the NRC request that they participate in the pilot program. Two of the other three projects were conducting or had conducted a third-party review as part of the Independent Design Verification Program (IDVP). In these cases, the completed or ongoing IDVP was used as the third-party audit evaluated in the pilot program.

4.1 TECHNICAL APPROACH AND FINDINGS

As with NRC's evaluation of the INPO CPE methodology for this report (Chapter 5), the four third-party audits were monitored and/or reviewed by senior NRC inspectors having extensive construction, design, QA, and management backgrounds. For each NRC evaluation, the activities of the third-party auditor

were monitored for several weeks at the plant site, at utility corporate headquarters, and/or at the offices of the A/E and the third party-auditor. The NRC evaluated the quality of the individual audits based on (1) the audit team's qualifications, (2) the audit team's competence and professionalism as demonstrated in the field, (3) the scope and depth of audit coverage in design, design control, construction procedures, completed construction work, quality assurance program implementation, and project management competence and capability, (4) the substance of audit findings, (5) the procedures used for reviewing and dispositioning audit findings, (6) the quality and content of the audit report, and (7) the independence of the inspector.

In conjunction with evaluating the quality of each audit, the NRC evaluated each audit considering the following questions:

(1) If this audit, or one like it, had taken place at an appropriate time in the project history of any of the five plants that experienced major quality-related problem(s), would the quality-related problem(s) at that plant have been detected earlier?

(2) Is this audit structured and conducted in such a way that it effectively verifies quality assurance program performance [i.e., alternative b(5)]?

(3) Could this audit, or some reasonable variation of it, be a way for a licensee to demonstrate that it is capable of independently managing the effective performance of all quality assurance and quality control responsibilities for the power plant [i.e., alternative b(2)]?

(4) Does this audit provide prevention, detection, and assurance capability beyond that provided by the NRC inspection program?

(5) If the answer to (4) is yes, are there more cost effective ways to bring about a comparable level of added detection and assurance capability?

(6) How often should such audits be conducted?

(7) Should such audits apply to future plants, to current CP holders, to both, or to neither?

The evaluation process led to the following conclusions and recommendations:

(1) Comprehensive audits of nuclear construction projects by qualified third-parties (independent inspectors) can significantly increase prevention and detection capability beyond that provided by the present NRC program. Such audits can also increase assurance that plants are built according to their design and licensing commitments.

(2) Alternative b(5) offers significant benefits over current and past practice. It should be adopted and applied to both future plants and current CP holders.

(3) Comprehensive third-party audits such as those examined in the pilot program, if modified to focus more on project management competence, present a viable mechanism for a new applicant to demonstrate in a post-CP

audit whether it can independently manage its QA program responsibilities and effectively manage the project. That is, an alternative b(5) audit could be used to satisfy the demonstration requirements of alternative b(2).

(4) Comprehensive audits of a construction project should be conducted about every two years.

(5) The present NRC CAT and IDI programs are limited in the extent of their coverage (4 CATs/yr, 3 IDIs/yr). Instituting a program of periodic third-party audits to supplement the present NRC program appears to be a more cost effective long-term approach than expanding NRC's program to a level that would provide the same degree of prevention, detection, and assurance coverage.

(6) The CAT and IDI programs should be used as overchecks of the third-party audit program.

(7) The NRC should develop criteria for independence of the third-party auditors and other criteria for the independent audit program, including qualifications of auditors, scope and depth of coverage, etc. Input from professionals having appropriate expertise and from other interested parties should be sought in developing these criteria.

(8) The NRC should monitor the actual performance of each audit and review its results.

(9) The depth and scope of each audit should be uniform and consistent to establish confidence in the third-party audit program. To achieve these goals and others, the third-party audit program should become a regulatory requirement.

4.2 PARAMETERS OF FUTURE THIRD-PARTY AUDITS

As a result of this study, the NRC staff has concluded that to provide sufficient preventive, detection, and assurance capability to feasibly supplement the NRC inspection program and affirmatively answer the first four questions in Section 4.1, the comprehensive independent audits recommended in the last section should, as a minimum, review the following areas in depth:

(1) experience, capability, and effectiveness of project management
(2) construction management
(3) management support of quality
(4) quality assurance program implementation
(5) qualifications of project personnel
(6) design process (A/E)
(7) design changes and control (A/E and site)
(8) quality of construction.

These categories are major areas relating to the ability of safety-related structures, systems, and components to function as required while in service. Other parts of this study also have identified other areas as being areas of weakness in the past (see Chapter 3, Case Studies). Design- and construc-

tion-related reviews in such an audit program should concentrate on whether the end product (design or system hardware) conforms with the technical requirements in the specifications and regulations, with licensee commitments made during the licensing process, and with the design basis. Such audits would measure the quality of the project team, project management, construction management, engineering, and the end results achieved by quality assurance programs. The design and construction quality reviews would be complemented by quality assurance program reviews that focused on implementing the procedural requirements of 10 CFR 50, Appendix B.

These reviews would be performed in conjunction with management reviews designed to assess the project team's effectiveness in managing all aspects of the project, including quality. The reviews should be both end-product oriented and process oriented. For example, designs would not only be audited to determine if they have been verified (a process required by Appendix B) but also reviewed for their technical adequacy (the end product). If the end product had deficiencies, then the process should be examined for generic implications. In the past, the NRC inspection program has concentrated too heavily on the quality program process and paper and not heavily enough on construction work in progress and the quality of the end product. Other measures being taken to address these shortcomings are discussed in Chapter 7.

Within the framework of the audit areas described above, a third-party audit should include sufficient review to satisfy the following performance objectives:

(1) assurance that the project team is capable of and is dedicated to constructing a nuclear power plant that, when operational, will not endanger public health and safety because of quality deficiencies that occurred during construction

(2) assurance that the project's programmatic controls for design and construction are adequate and have been adequately implemented

(3) assurance that the actual construction has been according to the design, and that design bases committed to by the applicant and approved by NRC have been translated correctly into the design

(4) assurance that the audit sample is broad enough to be reasonably representative of the plant as a whole.

Analysis of the results from the four independent audits revealed that while each has covered a part of the above proposed parameters and performance requirements for a third-party audit program, none has met all of them. Torrey Pines' construction assessment of Palo Verde did not include enough hardware verification, and Torrey Pines' assessment of the Marble Hill Project did not provide enough design or management review. The Gilbert review of South Texas was limited to programmatic controls, and the TERA review of Midland has not covered the areas of quality assurance or project management in enough detail.

A review of the four separate audit plans and their differences demonstrates that for future consideration NRC should develop audit criteria and should review in advance the audit plan of each auditor preparing for a third-party

audit to determine adequacy of coverage. Also, in determining the audit's scope, the NRC should consider such factors as percent of design completion, significant types of work in progress, results of previous third-party audits at this and other plants, NRC inspection results, and the state of project completion. This approach is supported by the NRC's experience over the past two years both in its implementation of a program of independent design and construction reviews for those plants in the near-term operating license mode (IDVP program--see Chapter 7) and through the CAT and IDI programs (see Chapter 7).

Periodic audits by independent inspectors throughout the construction period are strongly preferred over a single audit occurring late in a project after design and construction are essentially complete, as is the case presently for most plants (for IDVP and generally for CAT and IDI programs).

4.2.1 Frequency of Future Third-Party Audits

For each of the plants at which serious construction quality-related problems developed, symptoms of the quality problem were evident early in the project. Based on the experience of those plants, the proposed third-party audit program should be conducted no later than two years into construction and preferably sooner to achieve maximum effectiveness. For example, Marble Hill was shut down for construction quality problems 16 months after the CP was issued. Viewed as a prevention measure, the third-party audit should be conducted as soon as construction work begins, before poor practices become ingrained in the project. Viewed as a detection measure and a way to satisfy alternative b(2)'s concept of a demonstration of management and QA effectiveness, the licensee must have enough time to make its program work before the first audit. Based on these considerations and the assumption that in the future, applicants would receive a much more searching pre-CP review by NRC (see Chapters 2 and 7), which should help prevent unqualified project teams from beginning construction, the study concludes that the first of the third-party audits should be conducted 12 to 20 months into the construction project. This timing is early enough that the audit would still have some prevention value but not so early that the project team's capability and its quality program effectiveness cannot be meaningfully evaluated.

In determining the frequency of subsequent audits, several factors were considered: changes in projects, project personnel, contractors, and level of project activity in different areas. (A project proceeds through a sequence in which the level of activity in the following areas is high at one project phase and low at others: civil/structural, mechanical, electrical, instrumentation and control, testing and startup, etc.) The study concluded that subsequent audits should be conducted about every two years, depending on those factors.

The last third-party audit should focus heavily on design implementation (hardware and process) as well as startup and testing activities. However, the final audit would focus less heavily on design issues than the present IDVP program because the present program provides, on a case-by-case basis, a single third-party audit near the end of construction to confirm the quality of design and/or construction from the project outset. Under the proposed program, a less retrospective look would be required by the final audit because a comprehensive audit would have been conducted about every two years over the

project's life. Several of the areas covered by a current IDVP would have been covered under the new program in earlier audits. Those earlier audits would reduce the intensity of the final audit in some aspects from present practice. This reduced intensity would partly offset the increased effort the new program would require on the final audit in the areas of startup and testing, and management oversight of the transition from construction to operations. (For some background on transition problems, see Section 3.4.)

4.3. APPLICABILITY OF THE THIRD-PARTY AUDIT PROGRAM TO ALTERNATIVE b(2)

Section 13(b) of the Ford Amendment directs that the NRC analyze the following alternative approach to improving quality assurance and quality control in the construction of commercial nuclear power plants:

> Conditioning the issuance of construction permits for commercial nuclear power plants on a demonstration by the licensee that the licensee is capable of independently managing the effective performance of all quality assurance and quality control responsibilities for the powerplant.

The pilot program analysis included an evaluation of whether the third-party audit program proposed by alternative b(5) could also be used to satisfy the demonstration provision of this alternative. The study concluded that the first periodic audit conducted under the third-party audit program could be tailored to meet the demonstration requirement of alternative b(2) and that a third-party confirmation at this early point in construction was preferred to an NRC confirmation.

Including the b(2) demonstration as part of the third-party audit program is not the only way a licensee could achieve the performance objective implicit in alternative b(2). For example, the licensee could demonstrate this objective by an intensive NRC team inspection, such as a CAT modified to more directly address the issues of management capability and competence. However, the future program proposed by this study envisions a more rigorous screening by NRC before a CP is issued and an improved inspection program during construction. A third-party audit of the project 12 to 20 months into actual construction would not only provide assurance that the licensee's program is effective, but it would provide an independent test of the effectiveness of NRC's modified licensing and inspection programs. Such a third-party audit would provide Congress and the public increased assurance that not only the licensee but also the NRC met their responsibilities effectively.

When implemented, a post-CP demonstration of management capability and QA program effectiveness would significantly shift from present practice the method of determining whether the QA/QC program is being implemented as described in the Preliminary Safety Analysis Report (PSAR) and is producing an adequate level of quality. Including as a condition of the CP that such a demonstration occur 12 to 20 months after the CP is issued would place a "trip-wire" in front of the CP holder and the NRC. In effect, that "trip-wire" would specify that certain capabilities must have been demonstrated for plant construction to proceed beyond that point. Continuing construction activities would be contingent on the licensee successfully demonstrating its capability and program effectiveness in this post-CP audit. The licensee and the NRC

would be fully aware at the onset of construction that such a demonstration was upcoming. This awareness could result in several significant and beneficial changes from current practices:

(1) The CP holder should better understand the necessity to provide trained and qualified personnel and commit sufficient resources to the project at the beginning of construction activity.

(2) The CP holder would have to act rather than to react. Not only would a management system and quality program have to be instituted, but the CP holder would also have to critically evaluate its performance and convince itself of its effectiveness in order to be prepared to convincingly demonstrate its adequacy to others.

(3) Under such a CP condition, especially if the alternative b(2) audit were to be conducted by an independent third party, the NRC would be motivated to more closely monitor the project's management effectiveness, the QA program's effectiveness, and overall construction quality before the first audit. Besides doing a better job than under current practice for achieving prevention, detection, and assurance objectives, the NRC would have current information and an understanding of management of quality program weaknesses and possible needed changes. Such information would help NRC evaluate the CP holder's demonstration of management and QA effectiveness, whoever performs the confirming audit.

4.4 DESCRIPTION OF THE FOUR THIRD-PARTY AUDITS

This section describes the independent inspection programs at each of the four sites selected and discusses improvements that could be made in future reviews by independent inspectors. Each program is summarized, and Table 4.1 at the end of the chapter provides a summary comparison of the characteristics of each. The title of the independent audit and the name of the auditing firm is listed in the title of each section. Copies of each audit are available from each licensee and should also be held in NRC's Public Document Room. Presently, on a case-by-case basis (see Chapter 7 discussion of IDVP programs), the NRC staff formally reviews and evaluates independent audits, including corrective actions for any identified deficiencies, as part of the process leading up to issuing an operating license.

Two of the four audits, Palo Verde and Midland, were conducted under the auspices of the IDVP program. The NRC review described in this section was separate from the routine NRC review of IDVPs for licensing purposes; it was for the broader purpose of assessing the utility of comprehensive third-party audits as a supplement to the regular NRC inspection program. In particular, the analysis focused on whether third-party audits represented a viable improvement over current practice and whether such audits by independent inspectors should be required by regulation for all plants under construction. The audits were intended as examples for which this evaluation was performed and while adequate for their intended purpose, some did not cover areas that a comprehensive audit would be required to cover. These areas have been identified in Table 4.1 under the heading "Comprehensiveness".

4.4.1. Independent Construction Review of Marble Hill Nuclear Generating Station Units 1 and 2, Torrey Pines Technology, San Diego, California, 1983

Early in its construction, the Marble Hill project experienced problems with work being performed by the concrete contractor. The problem was attributed to breakdowns in the utility's and the contractor's management of the quality assurance programs and eventually resulted in an NRC Stop Work Order. After an 18-month investigation and a remedial action program, which included instituting stronger management and quality assurance programs, safety-related construction work was permitted to restart. This project was particularly relevant for the pilot program because of the early stage in which the Stop Work Order was issued and the apparent success of the remedial action program. (For further discussion on the dramatic improvement in the Marble Hill program, see Appendix A.)

Torrey Pines Technology (TPT) was selected as the independent consultant to conduct the audit. TPT was experienced as a third-party auditor, having performed similar reviews for other plants, including San Onofre and Palo Verde. The objective of the TPT program was to conduct an independent audit of the quality of construction of the Marble Hill Nuclear Power Station and to evaluate compliance with approved design documents for systems, hardware, and structures. This construction audit program consisted of a detailed evaluation in five task areas:

(1) evaluation of QA organization and management policies toward QA

(2) construction design control and implementation

(3) physical verification of plant hardware and structures

(4) testing and inspection of ASME piping welds and concrete

(5) construction document review.

As a result of the review, several deficiencies were identified and referred to Public Service of Indiana for corrective action. The proposed corrective actions were reviewed and approved by TPT and further evaluated by the NRC pilot program review team. The corrective actions appeared to be satisfactory.

The NRC reviewers judged the TPT methodology, amount of hardware inspected, and detail of inspection to be satisfactory. The absence of significant electrical construction review is consistent with the plant construction status and is not viewed as a deficiency. This independent construction review was considered to be representative of a comprehensive third-party construction verification effort of a plant at this stage of construction. TPT conducted a limited, but beneficial, design review effort at Marble Hill; however, it would not constitute adequate coverage of the design process when compared to other plants in the pilot study. The NRC pilot program reviewers judged the TPT assessment of the Marble Hill project to be adequate in the five areas reviewed by TPT. Design was not reviewed by TPT as a part of this audit because a similar plant of essentially the same design and having the same A/E had undergone an extensive design review by the NRC IDI team in June 1983.

The management assessment was confined mainly to the quality assurance organization and functions. Management issues would have to be more broadly evaluated to meet the evaluation parameters for future third-party audits described in Section 4.2.

4.4.2 Independent Design and Construction Verification Program - Midland Units 1 and 2, Monthly Status Reports Numbers 1 through 6, TERA Corporation, Bethesda, Maryland, 1983

The Midland Plant has experienced several quality-related problems during its construction, including excessive settlement of the diesel generator building and other safety-related structures. The licensee is currently conducting an extensive correction program to correct all deficiencies.

The TERA Corporation was selected to perform this review, which is still ongoing. TERA Corporation is a professional services and systems engineering organization that provides engineering and environmental consulting, project management, and software to industry and government.

The objective of the TERA review is to conduct an independent assessment of the quality of design and construction of the Midland Plant. The utility, TERA, and NRC staff defined the scope of review. The approach selected by TERA is to review and evaluate a detailed "vertical slice" (indepth review of many aspects of a selected system from design assumptions through completed construction, in contrast to a "horizontal slice," which looks at a few similar aspects of several systems) of three safety-related systems, and extrapolate from this review an overall assessment of the adequacy of the plant's design and construction.

Three areas were examined in the design assessment: the design criteria and commitments, their accuracy and consistency, and the implementing documents for design. Original calculations were checked, alternative calculations performed, and completed designs, including drawings and specifications, verified. Independent calculations performed by TERA incorporated both similar and different methods from the original design calculations.

The construction program review looked at supplier documentation, storage and maintenance documentation, and construction and installation documentation, and physically verified configuration and installation of selected systems and components.

As of January 1984, about 50% of the work scope of the TERA review had been completed, covering mainly Auxiliary Feedwater System design verification. Several deviations and deficiencies have been identified and some will require corrective action by the licensee. The disposition of these will be reviewed by the staff before the license is issued.

The TERA methodology, extent of design review, and the amount of hardware inspected were found to be satisfactory. TERA's review of the Consumers Power Company's (the utility) quality assurance program and management was limited, however. Coverage in these areas would have to be expanded to meet the parameters of future third-party audits described in Section 4.2. The use of checklists, periodic quality assurance audits of the independent inspectors,

and critiques of the TERA audit by senior level TERA management should result in a satisfactory review for the scope it covers. A final assessment of the adequacy of this audit will be made when it is completed.

4.4.3 Evaluation of South Texas Project - Units 1 and 2 Construction Project, Gilbert Commonwealth Associates, et al., 1983

The South Texas Project experienced several design and construction deficiencies in the late 1970s. These problems and allegations, some of which were later substantiated, and decisions by Houston Lighting and Power led to the replacement of the project's original A/E and construction manager (CM), Brown & Root. The engineering effort was transferred to the Bechtel Power Corporation, which was also designated as the CM, and Ebasco was assigned the constructor responsibilities.

Gilbert-Commonwealth Associates was selected as the independent audit team manager. Nineteen persons from Gilbert-Commonwealth Associates, Management Analysis Company, Nutech, and Energy Incorporated were selected to conduct the evaluation. The objective of the evaluation was to conduct an independent quality assurance evaluation of the South Texas Plant to ensure the adequacy of the design and construction. This audit was unique among the four in that the INPO evaluation criteria were used.

Two methods were used in the detailed design examination. First, INPO criteria were used to analyze the control of each step of the design process to determine whether it was sound and if it met the established requirements. Second, the evaluators reviewed a "vertical slice" of design activity. The system reviewed, the Component Cooling Water System, was examined in detail. The design team, in cooperation with the construction team, conducted a walkdown of the Component Cooling Water System to verify that it was constructed as the design specified. In addition, various in-process work activities were observed. The independent audit revealed weaknesses in design controls in interfaces with other contractors, engineering responses to Field Change Requests, construction drawings that were incomplete, and the utility's limited control of design changes. Several construction weaknesses were also identified.

The audit of the South Texas Project used the INPO performance objectives and criteria, which are mainly programmatic. The audit preparation, competence of evaluators, and review techniques were judged to be satisfactory. In the construction evaluation, only a limited number of weld radiographs were reviewed by the team. In the design evaluation, the scope of the review devoted to design was judged to be limited. Because of the known engineering problems of this site, a more substantial effort could have been performed in this area. In that regard, the staff understands that the licensee has a separate, continuing audit process for design. This audit would have to expand its coverage in these areas, as well as in management, to meet the parameters of future third-party audits (see Section 4.2).

4.4.4 Independent Quality Assurance Evaluation of Palo Verde Nuclear Generating Station, Units 1, 2, and 3, Torrey Pines Technology, San Diego, California, 1983

The Palo Verde Nuclear Generating Station is considered to be an example of a site at which quality assurance and quality control programs have operated satisfactorily.

TPT was also selected to perform this review. The overall objective of this effort was to independently evaluate project organization, management, quality assurance, design, and construction activities. The scope of TPT's review included activities of Arizona Public Service (APS) Company, Bechtel Power Corporation, and Combustion Engineering Corporation (the owner, A-E/CM, and nuclear steam supply system vendor, respectively). In the overall audit plan, which incorporated NRC comments and was approved by the NRC, five task areas were to be evaluated in detail:

(1) evaluation of project management organization

(2) evaluation of management's policies toward quality assurance

(3) evaluation of quality assurance activities

(4) design verification

(5) construction verification.

The objective of the first task was to evaluate APS's project management organization to determine the adequacy of its structure and organization and whether it could assure that the high standards required for nuclear power plant design, procurement, and construction had been met. The objectives of the second and third tasks were to review APS management policies that affect quality assurance and to assess the degree to which the policies ensure an effective quality assurance program. Also, specific elements of the APS quality assurance program were evaluated to determine if those elements were adequately defined and implemented.

The goal of the design verification, the fourth task, was to verify that the design bases contained in the Final Safety Analysis Report (FSAR) had been adequately converted into design documents for the constructor and fabricator. This task was divided into three subtasks consisting of design procedure review, design procedure implementation review, and a detailed technical review.

The final task, the construction verification review, was to verify the compliance of construction-related quality assurance procedures and controls with NRC requirements. Compliance was verified to evaluate the implementation of these procedures and controls and to determine whether selected safety-related systems and components were constructed according to design documents.

Valid deficiencies were referred to APS and their proposed corrective action was reviewed and approved by the TPT. The NRC review team further reviewed the corrective action, which appeared to be satisfactory.

The scope of review could have been broader. Specific areas not covered in this review are listed in Table 4.1, which summarizes the comparison of the independent audits of the four pilot programs. For example, more coverage of management issues, including the management of transition from construction to operations, would be required for this audit to meet the parameters for future third-party audits (see Section 4.2).

TABLE 4.1. Summary Comparison of Pilot Program Independent Audits

Project and Utility	A/E	Construction Manager	Constructor
Marble Hill, Public Service of Indiana	Sargent & Lundy	Utility	Various Contractors
Midland, Consumers Power Company	Bechtel (Ann Arbor)	Bechtel (Ann Arbor)	Bechtel (Ann Arbor)
South Texas Project, Houston Lighting & Power	Bechtel (San Francisco) (was Brown & Root)	Bechtel (San Francisco) (was Brown & Root)	Ebasco (was Brown & Root)
Palo Verde, Arizona Public Service	Bechtel (Los Angeles)	Bechtel (Los Angeles)	Bechtel (Los Angeles)

Project and Utility	Evaluation Consultant	Evaluation Schedule and Level of Effort
Marble Hill, Public Service of Indiana	Torrey Pines Technology (TPT) Average nuclear experience per team member was 10 years and each had participated in one or more similar evaluations.	6/3 - 7/23/83 8,000 person-hours total effort
Midland, Consumers Power Company	TERA Average nuclear experience per team member is 10 years with most of team having an average of 15 years.	6/83 - Mid 84 Total effort as of 9/83 estimated to be 20,000 person-hours
South Texas Project, Houston Lighting and Power	Gilbert-Commonwealth, Management Analysis Company NuTech, and Energy, Inc. Average nuclear experience per team member was 17 years. Members had on average participated in two similar evaluations.	8/22 - 9/2/83 4,000 person-hours total effort
Palo Verde, Arizona Public Service	Torrey Pines Technology (TPT) Average years of nuclear experience not identified - however, the Project Team Leader and key inspection team members were interviewed by NRC and found to be qualified and sufficiently experienced.	6/82 - 11/82 16,000 person-hours total effort

Project and Utility	Evaluation Scope
Marble Hill, Public Service of Indiana	° QA organization & management policies ° Construction design control & implementation ° Physical verification of plant hardware - Reactor coolant - Auxiliary feedwater - Component cooling - RHR - Fuel handling & auxiliary building - Ultimate heat sink ° Testing & inspection of ASME piping welds ° Construction document review
Midland, Consumers Power Company	° Design verification & construction verification ° Auxiliary feedwater, standby electric power, control room HVAC systems examined
South Texas Project, Houston Lighting and Power	° Design & construction evaluation - Component Cooling Water System - Used INPO methodology
Palo Verde, Arizona Public Service	° Project management organization ° Management's policies towards QA ° QA activities ° Design verification ° Construction verification

Project and Utility	Physical Verification Statistics
Marble Hill, Public Service of Indiana	° 21,000+ documents reviewed ° 13,000+ checks performed ° 56 welds visually inspected ° 49 weld radiographs reviewed ° 11 welders & welding inspector qualifications reviewed ° 67 hangers - installation features inspected ° 70 valves inspected ° 34 structural members inspected (beams, columns, guides, bracings, etc.) ° 34 areas of rebar inspected for proper location ° 50 areas of concrete tested for strength ° 22 hangers - detail verification ° 16 pieces of equipment inspected ° 25 cable tray hangers inspected ° 1800 feet of piping runs inspected
Midland, Consumers Power Company	° 50% of work scope conducted at time of preparation of this report; therefore, physical verification statistics not available
South Texas Project, Houston Lighting and Power	° 165 welds visually inspected ° 25 radiographs reviewed ° 15 welder qualifications reviewed ° 3000 feet of piping runs inspected ° 850 feet of cable trays inspected ° 140 pipe supports and cable tray hangers inspected ° 160 valves inspected ° 45 pumps inspected
Palo Verde, Arizona Public Service	° 15,000+ documents reviewed ° 15,000+ checks performed ° 55 welds visually inspected ° 48 welder or inspector qualifications reviewed ° 900 feet of piping runs inspected ° 68 hangers inspected ° 7 pieces of equipment inspected ° 50 feet of cable tray inspected ° 132 valves inspected ° 15 instrument wiring terminations inspected ° 55 instrument sensing elements, indicators and transmitters inspected

Project and Utility	Deficiencies Identified By Consultant
Marble Hill, Public Service of Indiana	° 19 Potential Deficiencies - 2 Valid - 8 Invalid - 9 Observations
Midland, Consumers Power Company	° 50% of work scope conducted at time of this report. Number of deficiencies identified to date is 10.
South Texas Project, Houston Lighting and Power	° 43 Potential Deficiencies - 13 safety-related - 30 nonsafety-related
Palo Verde, Arizona Public Service	° 89 Potential Deficiencies - 17 Valid - 31 Invalid - 41 Observations

Note: The four independent audits differed in scope, depth, and number of manhours (range of 4,000 to 20,000). Moreover, the evaluation criteria and the definitions of deficiencies varied from audit to audit. The reader should be aware of these nonuniformities in audits in evaluating the statistics on this page. The proposed third-party audit program would establish uniform audit criteria that would reduce the variations among audits and permit a more valid comparison among projects.

Project and Utility	Evaluation Program	
	Strengths	Comprehensiveness
Marble Hill, Public Service of Indiana	° Methodology, amount of hardware inspected and detail of inspections were judged to be satisfactory (absence of significant electrical construction review consistent with project status), and representative of a comprehensive third-party construction verification effort.	° Limited, but beneficial design review effort. However, the coverage afforded was not comparable to other programs evaluated under the pilot program. ° Management assessment was limited.
Midland, Consumers Power Company	° Program plan, methodology, extent of design review, amount of hardware inspected, use of checklists, use of periodic program plan QA audits and critiques by senior level management were judged to be satisfactory. A final assessment of the evaluation's adequacy will be conducted when the evaluation program is completed.	° Quality assurance and project management could have been reviewed in greater detail.

Evaluation Program continued on next page.

Project and Utility	Evaluation Program	
	Strengths	Comprehensiveness
South Texas Project, Houston Lighting and Power	° Preparation, competence of evaluators and inspection techniques were judged to be satisfactory.	° In construction evaluation a limited number of radiographs were reviewed. ° Limited level of effort devoted to design evaluation. ° Limited coverage of design controls and their implementation by the NSSS vendor. ° Review was limited to programmatic controls.
Palo Verde, Arizona Public Service	° Methodology, competence of evaluators, conduct of review under a QA program, which included periodic audits and reviews by a senior technical review committee and use of checklists for design review and physical verifications, were judged as satisfactory.	° The following areas would be expanded in the contemplated independent audit program: cross-section of welder qualifications, sample of weld radiographs, HVAC contractor's QA program, fire protection design, and broader look at critical equipment supplied by the NSSS vendor.