PEER 8 - Passive Institutional Controls Peer Review

CAO PLAN
Carlsbad Area Office

Title: Passive Institutional Controls (PICs) Peer Review Plan

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Date:

1. INTRODUCTION

This Passive Institutional Controls (PICs) Peer Review Plan describes the peer review process that will be implemented to confirm that the PICs proposed by the U.S. Department of Energy (DOE) at the Waste Isolation Pilot Plant (WIPP) will reasonably preserve the knowledge about the location, design, and contents of the WIPP disposal system and reduce the likelihood of inadvertent intrusion.

1.1 BACKGROUND

Under 40 CFR Part 191.12, PICS are defined by the Environmental Protection Agency (EPA) to include markers, public records and archives, government ownership of regulated or affected land, and other appropriate methods for preserving knowledge about the site. The assurance requirements found in 40 CFR Part 191.14(c) stipulate that "Disposal sites shall be designated by the most permanent markers, records, and other passive institutional controls practicable to indicate the dangers of their location." The regulatory requirements governing PICs, as specified in 40 CFR Part 191, are implemented through criteria in 40 CFR Part 194.43(a) requiring that "Any compliance application shall include detailed descriptions of the measures that will be employed to preserve knowledge about the location, design, and contents of the disposal system." The Carlsbad Area Office (CAO) has selected a method other than that suggested by the EPA in the preamble to 40 CFR Part 194 (61 FR 5232). In the preamble, expert judgment is suggested as the process for considering the specific PICs to be implemented at the WIPP by DOE in accordance with the requirements of 40 CFR Part 194.26. However, the language provided in 40 CFR Part 194.43 ("Passive Institutional Controls") makes no mention of the expert judgment process with regard to PICs, thereby allowing DOE the latitude to use the peer review as the means to evaluate the measures that DOE shall employ to preserve knowledge about the location, design, and contents of the disposal system. The "detailed descriptions" of these measures will be developed by DOE. The function of the PICs Peer Review Panel will be to confirm the "adequacy" and "reasonableness" of the detailed description, using a process conducted in accordance with NUREG-1297.

The requirements of NUREG-1297 state that "A peer review is a documented, critical review performed by peers who possess qualifications at least equal to those of the individuals who conducted the original work. These individuals must be independent of the work being reviewed. [I]ndependence from the work being reviewed means that the peer, a) was not involved as a participant, supervisor, technical reviewer or advisor in the work being reviewed, and b) to the extent practical, has sufficient freedom from funding considerations to assure the work is impartially reviewed."

To confirm that the PICs proposed by the DOE will reasonably preserve the knowledge about the location, design, and contents of the disposal system and reduce the likelihood of inadvertent intrusion, the DOE will conduct a peer review of the reports and analyses that document the systems to be employed. The peer review will be conducted to confirm the adequacy and reasonableness of the measures used to characterize PICs at the WIPP.
Under 40 CFR Part 194, the Compliance Certification Application (CCA) must address the impacts of PICs in restricting or deterring possible drilling and mining activities; this information must also be incorporated into the performance assessment (PA). Under 40 CFR Part 194.43(a), the CCA shall include detailed information regarding the PICs. A proviso is made in section 43(c) that while DOE may assume credit for the PICs reducing the likelihood

of human intrusion, it is understood that there is a limited time under which the PICs may be considered effective (i a period of up to 700 years).

1.2 PURPOSE

The purpose of this PICs Peer Review Plan is to define the peer review process that will be conducted to confirm that the detailed descriptions of the measures that will be employed to preserve knowledge about the location, design, and contents of the disposal system are adequate and have a reasonable expectation of meeting their intended purpose (i.e., reducing the likelihood of inadvertent intrusion) during the prescribed period of effectiveness.

1.3 SCOPE

This PICs Peer Review Plan describes the peer review process the DOE-CAO will implement for the review of the measures that will be employed to preserve knowledge about the design, location, and contents of the disposal system and reduce the likelihood of inadvertent intrusion. The Plan defines the approach, methodology, criteria, schedules, deliverables, and resources that the PICs Peer Review Panel will use to confirm the adequacy and reasonableness of the measures DOE intends to use to demonstrate compliance.

2. PEER REVIEW PLANNING AND IMPLEMENTATION

2.1 APPROACH

The DOE-CAO has prepared the "Office of Regulatory Compliance (ORC) Team Procedure for Peer Review" (TP 10.5) to document the approach for conducting peer reviews. The PICs Peer Review Panel will conduct the peer review activities for the evaluation of PICs measures in accordance with TP 10.5 and this PICs Peer Review Plan. A DOE-CAO contractor, Informatics, Inc., has developed Informatics Desk Instruction (IDI) 1.0 that will be used in conjunction with TP 10.5.

The data and information necessary to support the PICs Peer Review has been prepared by those CAO participating organizations responsible for preparation of the PICs reports and analyses.

2.1.1 DATA USED IN THE DEMONSTRATION OF COMPLIANCE

The "PICs Efficacy Report," "PICs Conceptual Design Report," and supporting data and information will serve as the inputs to the PICs Peer Review.

2.1.2 COMPOSITION OF PEER REVIEW PANELS

The PICs Peer Review Panel will be composed of a minimum of three individuals who will represent the spectrum of experience required to review the documentation and analyses and to develop the PICs Final Report. The Peer Review Selection Committee will identify and select the Panel member(s) based on the candidates' ability to meet the peer reviewer requirements as defined in TP 10.5.

2.1.3 LOGISTICS AND MANAGEMENT

When the PICs Peer Review Panel convenes, Panel members will receive formal orientation and training. The orientation will help to familiarize Panel members with the WIPP disposal system, the regulatory and technical basis of the PICs, and their intended impact on reducing the potential for future human intrusion, through either drilling or mining activities within the WIPP controlled boundaries, during the period of the PICs' regulatory effectiveness. Each peer reviewer will be selected, oriented, and trained in accordance with approved procedures.

It is the intention of DOE-CAO to have the PICs reports and other data available for review when th. PICs Peer Review Panel begins the review process. However, not all information necessary to support peer review of the PICs documents will be available at the beginning of the review. It may be necessary,

therefore, to conduct the PICs Peer Review in a phased manner, depending upon the availability of the information.

2.2 METHODOLOGY

The PICs Peer Review will be conducted in accordance with the general guidance provided in NUREG-1297. Requirements for developing the methodology are presented in TP 10.5 which states that "suggested methods" shall be included in the specific Peer Review Plan. The PICs Peer Review Panel will also refer to 40 CFR Part 194.43 for specific guidance as it reviews PICs documents and other related information.

2.3 ADEQUACY CRITERIA

Adequacy of data associated with the PICs will be based on the PICs Peer Review Panel's determination that these data meet commonly accepted technical and scientific standards. Criteria stipulated in NUREG-1297 include, as applicable:

1. Adequacy of requirements and criteria;
2. Validity of assumptions;
3. Alternate interpretations as appropriate;
4. Uncertainty of results and consequences if wrong;
5. Appropriateness and limitations of methodology and procedures;
6. Adequacy of application;
7. Accuracy of calculations; and
8. Validity of conclusions.

In its review, the PICs Peer Review Panel may also consider, as appropriate, the following:

- The sources of the parameters and data, e.g., professional judgment, published source material, field tests, laboratory experiments, etc.;
- The processes used to produce the parameters from data are appropriate for the intended use; and
- The assumptions, calculations, extrapolations, interpretations, methods, and conclusions pertinent to the data are appropriate for the development of parameters used as input to the WIPP PA and are traceable.

2.4 SCHEDULE

The PICs Peer Review Panel review is expected to last between three to four weeks. The Peer Review Manager, working closely with the CAO-ORC staff, has developed a preliminary schedule that provides the necessary information in a manner that will allow the final report to be developed in accordance with the schedule shown in Attachment A. This schedule will serve as the baseline schedule from which requested schedule deviations may be evaluated and approved, if appropriate. Revisions to the baseline schedule will not require revision to this Plan but will be attached to the Plan by reference.

2.5 RESOURCES

The resource needs for completing the PICs Peer Review are listed in Attachment B.

2.6 REPORT FORMAT

A list of mandatory topics and a suggested outline for the Peer Review Final Report is provided in Attachment C.

3. QUALITY ASSURANCE

The PICs Peer Review will be conducted in a controlled manner and in compliance with TP 10.5.

4. RECORDS MANAGEMENT

Records and documents generated as a result of the peer review activities defined in this Peer Review Plan are identified in TP 10.5. Records will be assembled and maintained in accordance with the Peer Review Management Plan and IDI 1.0. Upon completion of the PICs Peer Review, a complete set of PICs Peer Review records will be delivered to the DOE-CAO. Ultimately, the PICs Peer Review records will be dispositioned in accordance with DOE-CAO records management requirements defined in CAO-MP 4.5.

5. DOCUMENT CONTROL

All plans, procedures, and other documents which require document control will be handled in accordance with applicable DOE-CAO controlled document procedures defined in CAO-MP 4.4.

ATTACHMENT A

TENTATIVE SCHEDULE

PANEL REVIEW -- MEETING 1

May 28

8 a.m. - 12 p.m.	Administrative Orientation
1 p.m. - 5 p.m.	Review Training Materials

May 29

8 a.m. - 3 p.m.	Background Information on WIPP Review Background Information Meet with Panel

PANEL REVIEW -- MEETING 2

June 4

3 p.m.	Travel to Carlsbad (4:05 flight)

June 5

8 a.m. - 5 p.m.	WIPP Site and Facility Tour (pick-up at hotel by Westinghouse at 8 a.m.

June 6

8 a.m. - 12 p.m.	Technical Presentation at DOE
12 p.m.. - 4 p.m.	Travel to Albuquerque (1:05 p.m. flight)

June 7

???	Optional meeting in Albuquerque

TBD -- Conference calls and express mail exchanges, as needed

PANEL REVIEW -- MEETING 3

June 24 - 27

TBD	Peer Review Work Session

DRAFT DOCUMENT DUE	***June 20, 1996***
FINAL DOCUMENT DUE	**June 27, 1996**

ATTACHMENT B

ESTIMATED PEER REVIEW RESOURCE REQUIREMENTS

Subject Matter Experts	1,200 hours
Technical Coordinator	300 hours
Clerical Support	300 hours

ATTACHMENT C

SUGGESTED OUTLINE FOR PEER REVIEW REPORT

Executive Summary

1. Introduction
2. Purpose
3. Description of Work Performed
4. Evaluation Work Performed
    a. Adequacy of Requirements and Criteria
    b. Validity of Assumptions
    c. Alternate Interpretations
    d. Uncertainty of Results and Consequences if Wrong
    e. Appropriateness and Limitations of Methodology and Procedures
    f. Adequacy of Application
    g. Accuracy of Calculations
    h. Validity of Conclusions
5. Conclusions
6. Dissenting Views
7. Summary
8. Signatures
9. Peer Review Members and Acceptability

PASSIVE INSTITUTIONAL CONTROLS QUALIFICATION

PEER REVIEW REPORT

FINAL REPORT

WASTE ISOLATION PILOT PLANT
PASSIVE INSTITUTIONAL CONTROLS
PEER REVIEW REPORT

A PEER REVIEW

CONDUCTED BY

Jessica Glicken, Elizabeth Hocking, Paul La Pointe

for

U.S. Department of Energy

Carlsbad Area Office

Office of Regulatory Compliance

July 1996

FOREWORD

The U.S. Environmental Protection Agency promulgated "Criteria for the Certification and Recertification of the Waste Isolation Pilot Plant's Compliance with the 40 CFR Part 191 Disposal Regulations Final Rule" in Code of Federal Regulations Title 40, Part 194 (40 CFR Part 194) on February 9, 1996. The 40 CFR Part 194 regulation prescribes three specific peer reviews and provides an opportunity for the U.S. Department of Energy to use peer reviews, conducted in accordance with NUREG 1297, as a means of qualifying data and information in the demonstration of compliance.

This report contains the results of a peer review of passive institutional controls used in the demonstration of Waste Isolation Pilot Plant compliance with 40 CFR Part 194. To ensure the independence of this review, the Department of Energy has directed the assignment of an independent contractor to administratively manage the peer review activities. Peer reviewers were selected based on their demonstrated independence from the work being reviewed and their technical expertise in the subject matter. The peer review panel members collectively possess an appropriate spectrum of knowledge and experience in the subject matter reviewed.

This peer review was conducted in compliance with the quality assurance requirements as defined in 40 CFR Part 194.

CONTENTS

FIGURES

ACRONYMS

CAO	Carlsbad Area Office
CAG	Compliance Application Guidance
CCA	Compliance Certification Application
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
EEG	Environmental Evaluation Group
EPA	U.S. Environmental Protection Agency
FR	Federal Register
NRC	U.S. Nuclear Regulatory Commission
PA	Performance assessment
PIC	Passive institutional control
PTF	Passive Institutional Controls Task Force
SNL	Sandia National Laboratories
TP	Team Procedure (Carlsbad Area Office)
WIPP	Waste Isolation Pilot Plant

1.0 EXECUTIVE SUMMARY

The Waste Isolation Pilot Plant (WIPP) is a proposed repository of transuranic waste located in Carlsbad, New Mexico. Owned and operated by the U.S. Department of Energy (DOE), WIPP is scheduled to open in 1998 and will be in operation until the year 2033 (estimated). Upon closure of WIPP, DOE is required to maintain active institutional controls at the 16-square-mile disposal site for 100 years. Following the end of the period of active controls, DOE intends to rely upon a variety of passive institutional controls to warn and inform future societies about the presence of WIPP and the nature of its contents. These passive institutional controls will include berms, stone markers or monoliths, buried record storage rooms, land use records (e.g., drilling permits), and archival information placed at various libraries, government buildings, and other centers in the United States and abroad.

During a 5-week period beginning in May 1996, a three-member panel of experts was convened to conduct an independent peer review of the system of passive institutional controls designed by DOE. The panel reviewed the findings of the Passive Institutional Controls Task Force (PTF), evaluating detailed descriptions of the measures DOE has proposed to preserve knowledge about the location, design, and contents of the WIPP disposal system. The primary focus of the evaluation was to determine whether the passive institutional controls designed by DOE are adequate and have a reasonable expectation of meeting their intended purpose of reducing the likelihood of inadvertent intrusion during the prescribed period of effectiveness (i.e., approximately 700 years). The results of the panel's review are documented in this report.

In preparation for their peer review, panel members familiarized themselves with requirements regulating activities at WIPP (40 Code of Federal Regulations [CFR] Parts 191 and 194) and requirements for the conduct of peer reviews (NUREG-1297 and Carlsbad Area Office Team Procedure [TP] 10.5). Following briefings by members of the PTF, panel members were given two documents that formed the basis of their peer review: *Effectiveness of Passive Institutional Controls in Reducing Inadvertent Human Intrusion into the Waste Isolation Pilot Plant for Use in Performance Assessments* (hereinafter referred to as the *PICs Efficacy Report*) and *Passive Institutional Controls Conceptual Design Report* (hereinafter referred to as the *Conceptual Design Report*). Supplemental information requested by the panel was also used in the evaluation.

The approach used by the peer review panel was to evaluate the assumptions and results presented in the *PICs Efficacy Report* using the following criteria: adequacy and legitimacy of assumptions, appropriateness and accuracy of the methodology used to develop and assess the assumptions and the

failure probability of the passive institutional controls, uncertainty associated with the credit calculations, consequences of inaccurate or incomplete assumptions, and validity of the conclusions. The panel's findings relating to these criteria are presented below.

1.1. Adequacy and Completeness of Assumptions

In general, the panel found that the PTF's interpretation of the regulations regarding passive institutional controls was adequate and reasonable given the indeterminate quality of some of the regulations. However, the panel expressed concern about the way in which the PTF's interpretations were applied. In many cases, the panel found the PTF's assumptions to be reasonable but unsupported and/or incomplete. In other cases, the panel determined that the PTF failed to discuss assumptions that were: 1) implicit in, and necessary to, the assumptions they presented, or 2) made by expert panels and incorporated into the overall design of the passive institutional controls (e.g., validity of archetypes as a communications vehicle).

Another area of concern dealt with the PTF's failure to develop and/or discuss the communications and activities process models that underlie the conceptual design of the controls. Such models would: 1) look at passive institutional controls as communications vehicles, and 2) assume a general pattern of activity that will lead to an inadvertent intrusion event.

The panel's assessment of the individual assumptions presented in the *PICs Efficacy Report* resulted in a consensus about the general adequacy and reasonableness of the information contained in the document. However, panel members noted their concern about areas within the *PICs Efficacy Report* that may be in need of clarification or modification. These include:

- ***Basic human attributes.*** Several assumptions regarding human characteristics are poorly supported or in need of other modifications. For example, explicit assumptions should be provided relating to human evolution and associated biological and sociocultural capabilities.
- ***Government.*** The PTF does not adequately define "government" and offers poor support for the assertions made in the *PICs Efficacy Report*. Also, some of the assumptions made by the PTF are actually conclusions or second-order assumptions.
- ***Language.*** Assumptions made by the PTF should be supported by references. Also, assumptions regarding other aspects of communication are not captured.
- ***Natural resources.*** The panel found these assumptions to be generally reasonable and consistent with the requirements.

- ***Estimating the effectiveness of passive institutional controls.*** Four assumptions are made that require additional support. Furthermore, the panel believes that social institutions other than government should be considered as potential facilitators of passive institutional controls since there are strong and effective mechanisms of social control other than government.

1.2. Adequacy of the Technical Presentation

In addition to evaluating the adequacy and completeness of the assumptions made by the PTF, the peer review panel evaluated the adequacy of the PTF's technical presentation using the following criteria:

- ***Application of the systems approach.*** The panel found that the redundancy of the individual components was well-supported and explained, but that the sufficiency of the individual components to effectively deter inadvertent intrusion in the absence of any other component was unevenly supported. The panel noted the PTF's failure to discuss the "Gestaltic" nature of the system, in which the whole is more effective in deterring intrusion than the sum of its parts.

- ***Assessment of the durability and comprehensibility of individual components of the system.*** The panel examined descriptions of markers, archives, records centers, government control of land use, and other passive institutional controls. The panel concluded that the materials (e.g., granite) and plans for the storage and retention of records appear to be adequate, but that there is uncertainty attached to both the durability and comprehension of all passive institutional controls and that this uncertainty has not been taken into account by the PTF.

- ***Assessment of completeness of failure scenarios.*** The panel found that at least two failure scenarios were not discussed by the PTF: collateral damage due to war and inadvertent intrusion due to horizontal drilling.

- ***Evaluation of credit calculations.*** The panel's analysis suggested that the PTF's credit calculations may be incorrect or incomplete. For example, failure rates and the uncertainty surrounding failure rates should be calculated for each component.

- ***Consequences for performance assessment.*** The panel concluded that: 1) uncertainties relating to the failure of various passive institutional controls components were not addressed properly, 2) certain credible failure scenarios were not considered, 3) adequate evidence for calculating failure probabilities of various components was not provided, and 4) the systems nature of passive institutional was not appropriately considered when calculating the probabilities that individual components and/or the system will fail.

The overall conclusions presented by the panel regarding the passive institutional controls described and supported in the *PICs Efficacy Report* and the *Conceptual Design Report* suggest that: (1) the evidence provided in the reports does not adequately demonstrate that passive institutional controls will have a failure probability of 0.01 or less and (2) the level of uncertainty as it applies to the passive institutional controls is higher than 0.0.

2.0 INTRODUCTION

The Waste Isolation Pilot Plant (WIPP) is a proposed repository of transuranic waste located in Carlsbad, New Mexico. Owned and operated by the U.S. Department of Energy (DOE), WIPP is scheduled to open in 1998 and will be operational until the year 2033 (estimated). Upon closure of WIPP, the DOE is required to maintain active institutional controls at the 16-square-mile disposal site for a period of 100 years. At the end of the period of active controls, DOE intends to rely upon a variety of passive institutional controls (PICs) to warn and inform future societies about the presence of WIPP and the nature of its contents. These passive institutional controls will include berms, stone markers or monoliths, buried record storage rooms, land use records (e.g., drilling permits), and archival information placed at various libraries, government buildings, and other centers in the United States and abroad.

Beginning in May 1996, a three-member panel of experts was convened to conduct an independent peer review of the passive institutional controls system designed by DOE. The panel was one of five peer review panels that were appointed to assess various elements of WIPP to determine whether the work done by DOE and its contractors met the requirements of adequacy and reasonableness set forth in guidance developed by the U.S. Nuclear Regulatory Commission (NRC), Peer Review for High-Level Nuclear Waste Repositories, commonly known as NUREG-1297 (NRC 1988). Using the peer review process to evaluate components of the WIPP disposal system is authorized by 40 Code of Federal Regulations (CFR) Part 194, and is to be conducted in accordance with NUREG-1297. The findings of these panels will be considered by DOE in preparing the Compliance Certification Application (CCA) that will be submitted to the U.S. Environmental Protection Agency (EPA) to signify DOE's readiness to accept waste at WIPP.

The three members of the Passive Institutional Controls Peer Review Panel worked during a 5-week period to review the findings of the Passive Institutional Controls Task Force (PTF) led by Sandia National Laboratories (SNL). The panel evaluated the adequacy and reasonableness of the detailed descriptions of the measures that will be employed to preserve knowledge about the location, design, and contents of the WIPP disposal system. The primary focus of the evaluation was to determine whether the passive institutional controls designed by DOE are adequate and have a reasonable expectation of meeting their intended purpose (i.e., reducing the likelihood of inadvertent intrusion) during the prescribed period of effectiveness (approximately 700 years). This report presents the results of the panel's evaluation.

The following sections describe the review and evaluation process undertaken by the peer review panel and the results of the process. Section 3 describes the work performed, including methods and resources used by the panel. Section 4 evaluates the validity of assumptions made by the PTF with regard to the various passive institutional controls and their effectiveness. Section 5 evaluates the adequacy of the technical presentation. Section 6 presents the panel's conclusions and summary. Section 7 consists of a signature page, with signatures indicating passive institutional controls panel members' concurrence with the findings and conclusions of the report. Section 8 provides a brief description of each panel member's education and relevant experience. References are provided in Section 9.

3.0 DESCRIPTION OF WORK PERFORMED

The peer review for passive institutional controls was initiated on May 28, 1996, with a 1-day administrative orientation and training session in Albuquerque, New Mexico. The session allowed the peer review panel members to familiarize themselves with the primary regulations and other guidance relevant to WIPP and the peer review process, including:

- 40 CFR Part 191, *Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes.*
- 40 CFR Part 194, *Criteria for the Certification and Re-certification of the Waste Isolation Pilot Plant's Compliance with the 40 CFR Part 191 Disposal Regulations.*
- NUREG-1297, *Peer Review for High-Level Nuclear Waste Repositories.*
- Carlsbad Area Office (CAO) Team Procedure 10.5 (TP 10.5), *Peer Review.*

The initial training was supplemented with reports on the activities of the Futures and Markers panels; these reports were provided to panel members by SNL.

The panel members were given a technical orientation in Carlsbad, New Mexico, on June 5 to 6, 1996. On June 5, panel members were given a tour of the WIPP site and surrounding area to acquaint themselves with the facility and the general layout of the 16-square-mile area that encompasses WIPP. On June 6, panel members met for briefings by representatives of DOE-CAO, SNL, and their subcontractors who had participated in the PTF. Following the briefings, panel members were given two documents: *Effectiveness of Passive Institutional Controls in Reducing Inadvertent Human Intrusion into the Waste Isolation Pilot Plant for Use in Performance Assessments* (Trauth et al. 1996) (hereinafter referred to as the *PICs Efficacy Report*) and *Passive Institutional Controls Conceptual Design Report* (DOE 1996a) (hereinafter referred to as the *Conceptual Design Report*). These two reports, together with supplemental information requested by the panel, were the basis of the peer review of the system of passive institutional controls designed by DOE.

In its review of documentation prepared by SNL, the peer review panel followed the requirements set forth in NUREG-1297 and 40 CFR Part 194 regarding the conduct of peer reviews and the development of passive institutional controls. Although panel members were aware of the CCA content requirements for passive institutional controls, their evaluation was guided not by the *Compliance Application Guidance* (CAG) for 40 CFR Part 194 developed by EPA to assist in preparation of the CCA, but by the requirements of 40 CFR Part 194 (EPA 1996a). Panel briefings, deliberations, meetings, information

requests, and records management were conducted in accordance with TP 10.5 and Informatics Desk Instruction 1.0.

The adequacy criteria in NUREG-1297 provided guidance for the review of the documents and processes being evaluated. The following evaluation criteria were applied by the peer review panel to the assumptions underlying the development and assessment of passive institutional controls:

- Completeness of the assumption (legitimacy and adequacy of assumptions).
- Appropriateness and accuracy of methodology used to develop and assess the assumptions and the passive institutional controls.
- Uncertainty associated with the credit calculations.
- Consequences associated with inaccurate or incomplete assumptions.
- Validity of conclusions.

During the peer review process, panel members were able to request any supporting information they required, including reports, regulations, and presentations by or question/answer sessions with representatives from SNL, DOE-CAO, EPA, and the Environmental Evaluation Group (EEG). The information provided by these resources was discussed during panel meetings and conference calls during June 1996. The various resources used by the panel are cited throughout the report and are compiled in Section 9.

The composition of the peer review panel followed the guidance of NUREG-1297 that peer reviewers have technical qualifications that are "at least equivalent to those needed for the original work under review." Due to the nature of the work being reviewed, peer reviewers were also selected on the basis of their diverse backgrounds. The names and areas of expertise of the Passive Institutional Controls Peer Review Panel members are: Jessica Glicken, Ph.D., Cultural Anthropology; Elizabeth Hocking, J.D., Environmental Law; and Paul La Pointe, Ph.D., Natural Resources Engineering. Additional information about the panel members is provided in Section 8.

4.0 ASSUMPTIONS

4.1. Interpretation of Regulations Regarding Passive Institutional Controls

4.1.1. Definitions and Descriptions

Passive institutional controls are defined in 40 CFR 191 as:

> (1) Permanent markers placed at a disposal site, (2) public records and archives, (3) government ownership and regulations regarding land or resource use, and (4) other methods of preserving knowledge about the location, design, and contents of a disposal system (40 CFR Part 191.12).

Passive institutional controls are identified at 40 CFR Part 191.14 as one of the provisions that must be followed in the disposal of transuranic wastes to ensure that the waste containment requirements of 40 CFR Part 191.13 will be met. The regulation states that:

> Disposal sites shall be designated by the most permanent markers, records, and other passive institutional controls practicable to indicate the dangers of the wastes and their location (40 CFR Part 191.14(c)).

40 CFR Part 194 refers to passive institutional controls as the "measures that will be employed to preserve knowledge about the location, design, and contents of the disposal system." Details of the elements these measures must include are provided in 40 CFR Part 194.43(a). In brief, passive institutional controls must include:

- Markers designed, fabricated, and emplaced to be as "permanent as practicable" to identify the controlled area.
- Records placed in archives and record systems "that would likely be consulted by individuals in search of unexploited resources." These records will describe the location and characteristics of the disposal system and wastes.
- Other controls that would "indicate the dangers of the waste and its location" (40 CFR Part 194.43(a)).

Although the *PICs Efficacy Report* discusses markers, records, and other controls, its quotation of 40 CFR Part 194.43(a) is not an accurate or complete representation of "the measures that will be employed to preserve knowledge" of the site and its dangers (p. 2-3). The quotation lists markers as the only measure; it ignores the reference in the regulation to records and other controls even though the regulation states that all three types of passive institutional controls "shall" be included as measures.

While this may be an oversight, this section should be revised to avoid the appearance that the PTF is minimizing the role of records and other passive institutional controls.

4.1.2. Active Institutional Controls versus Passive Institutional Controls

Active institutional controls are described in the regulations as:

> (1) Controlling access to a disposal site by any means other than passive institutional controls. (2) performing maintenance operations or remedial actions at a site, (3) controlling or cleaning up releases from a site, or (4) monitoring parameters related to disposal system performance (40 CFR Part 191.12.)

Neither the regulations nor the CAG includes any further discussion of active institutional controls (other than restricting their credit value to a maximum of 100 years) as opposed to passive institutional controls.

In the *PICs Efficacy Report*, the PTF draws a distinction between active institutional controls and passive institutional controls. In the former, an institution deters intrusion; in the latter, the institutional control itself is the deterrent (p. 2-2). This distinction is a reasonable interpretation of the regulations, given their indeterminate quality. In the course of its discussion, the PTF expanded on the distinction between the two types of controls by stating that passive institutional controls are intended to control, allow, or disallow certain activities that would take place whether the repository existed or not. Active institutional controls are intended to control, allow, or disallow activities that are repository-specific (Trauth 1996). However, this definition ignores the marker system that is described in the regulations as a passive institutional control and that would only be in existence because of the repository. The PTF may want to consider providing examples of both active institutional controls and passive institutional controls to delineate the distinction between the two for performance assessments.

4.1.3. Future States Assumptions

Because EPA wished to minimize the potentially endless speculation about the future states that passive institutional controls must serve, 40 CFR Part 194 requires the developers of passive institutional controls to assume that the "characteristics of the future remain what they are at the time the compliance application is prepared" with the exception of hydrogeologic, geologic, and climactic conditions (40 CFR Part 194.25(a)). Although the regulations say nothing more about future state assumptions, EPA states that there are:

> . . . certain societal 'common denominators' . . . that could be considered in the discussion of [passive institutional controls]. These common denominators are patterns of human behavior that may be detected throughout history and around the world (CAG, p. 61).

The EPA lists the following as examples of these societal common denominators:

- Existence of some form of government and some level of regulatory control over the exploration for and development of resources.
- Ability of pictures to convey meaning.
- Curiosity of humans.
- Expectation that some people will avoid, ignore, or be ignorant of governmental controls.
- Use of the written word to transmit information and concepts.
- Storytelling or the generational 'passing down' of history (CAG, p. 61).

EPA describes this list as not comprehensive and expects DOE to "establish a framework of assumptions for [passive institutional controls] that is a prudent extrapolation of the future state assumptions" (CAG, p. 60). Thus, the regulations and accompanying guidance grant DOE almost complete freedom to develop future state assumptions for the development of passive institutional controls as long as it can "demonstrate—based on the particular measures at issue and documented, reasoned justification—why any assumptions made in these circumstances are sound" (CAG, p. 60).

The peer review panel believes that the PTF has interpreted this requirement correctly. The PTF's execution of the interpretation is evaluated in Section 4.2 of this report.

4.1.4. Expert Judgment and Peer Review

The use of expert judgment, either by an individual expert or a panel of experts, is permissible under 40 CFR Part 194.26(a) to support the information in the CCA if that information cannot reasonably be obtained through data collection or experimentation. The preamble to the rule includes the statement that one of the situations in which expert judgment is typically used is to elicit "essentially unknowable information, such as which features should be incorporated into passive institutional controls that will deter human intrusion into the repository" (61 Federal Register [FR] 5224, 5228). Although the preamble language specifically describes passive institutional controls as a prime subject for the use of expert judgment, and states that "DOE's proposed reduction in the likelihood of human intrusion due to [passive institutional controls] would probably be conducted through an expert judgment process" (61 FR 5224,

5232), the actual regulation is silent on the role of expert judgment in the development and assessment of passive institutional controls. Indeed, the rule does not even require that expert judgment be used to support the CCA when information cannot be supported through data collection and experimentation; it simply says that expert judgment "may" be used in those instances (40 CFR Part 194.26(a)).

Part 194.27(a)(1) of 40 CFR requires conceptual models selected and developed by the DOE to be peer reviewed. The rule does not define conceptual models.

The conceptual design principles presented in the *Conceptual Design Report* seem to rely heavily on the results of the expert judgment process described in Trauth et al. (1992). However, the future state assumptions relied upon in the *PICs Efficacy Report* either are based on the examples cited in the CAG or are attributed to the PTF.

Since the regulations do not clearly define passive institutional controls as a conceptual model, thereby requiring neither peer review nor expert judgment, the process of developing and assessing passive institutional controls is essentially unregulated (although it is guided by the regulations). The PTF and preparers of the *Conceptual Design Report* have somewhat blurred the line between reliance on expert judgment and the peer review process by incorporating both processes; their approach is certainly not precluded by the regulations. Section 1.4 of the *PICs Efficacy Report* does describe the four-step process used to develop and assess passive institutional controls, but the reasoning behind the process is not explained (pp. 1-7 to 1-8). The regulations do not require such an explanation, but the documents may be strengthened if an explanation is included.

4.1.5. Credit for Passive Institutional Controls

DOE may receive credit, in the form of reduced likelihood of human intrusion, for its passive institutional controls if it demonstrates that credit is warranted because the controls are expected to endure, and be understood by potential intruders, for the time period approved by EPA (40 CFR Part 194.43(c)). The regulation states that the credit shall not be extended to more than several hundred years, although the preamble to the rule states that credit can be given for up to 700 years (61 FR 5224, 5231).

EPA states that DOE's expectation that passive institutional controls will endure is "likely to require a deterministic analysis, based on scientific data, that takes into account" future state assumptions based upon societal common denominators (CAG, p. 60). EPA expects that the second aspect of the effectiveness determination for passive institutional controls (i.e., that they be understood by potential intruders) will "require qualitative analysis and discussion" (CAG, p. 60).

Part 191.13(b) of 40 CFR clarifies that a "reasonable expectation" of assurance with the containment requirements is called for in the performance assessments rather than "complete assurance" because of the "substantial uncertainties in projecting disposal system performance." Therefore, although the use of passive institutional controls at WIPP is required to ensure compliance with disposal requirements (e.g., 40 CFR Part 191.14), proof of that assurance need not be asserted with complete certainty. The PTF assumes that the "reasonable expectation" requirement of 40 CFR Part 191.13(b) also applies to the estimation of the effectiveness of passive institutional controls and that "absolute proof of the longevity of a marker, a records system, or a message is neither achievable nor required to take credit for passive institutional controls in the [performance assessment] calculations" *(PICs Efficacy Report*, pp. 2-5 to 2-6). This assumption is in accordance with the regulations and the CAG.

4.1.6. "Practicability" Considerations

The PTF states that the conceptual design for passive institutional controls "requires the consideration of what is 'practicable'" *(PICs Efficacy Report*, p. 5-1). The *Conceptual Design Report* relies on a practicability evaluation of the three marker design options to select the preferred option. 40 CFR Parts 191.14(c) and 194.43 incorporate practicability considerations but do not include a definition. The PTF's interpretation of, and reliance upon, practicability of passive institutional controls is appropriate.

4.1.7. Deterring Inadvertent Human Intrusion into the Area of Concern for Drilling

The peer review panel believes that the PTF accurately interprets the nature of inadvertent human intrusion that must be protected against. It defines the area of concern for this intrusion as the repository and the Withdrawal *(PICs Efficacy Report*, p. 2-7). The regulations in 40 CFR Parts 194.32 and 194.33 require that the effects of inadvertent drilling and mining on the "disposal system" be considered, but do not define the disposal system precisely as the repository footprint or the Withdrawal. Part 143.43(a)(1) of 40 CFR does require "identification of the controlled area by markers" and 40 CFR Part 191.12 defines the controlled area and describes it in relation to the accessible environment.

Although the regulations are silent on the definition of the disposal system, the preamble to 40 CFR Part 194 does reference the effects of mining in the "Land Withdrawal Area" (61 FR 5224, 5233). The peer review panel believes that, in assuming the areas of concern to be addressed by the passive institutional controls are the footprint and the Withdrawal, the PTF is reasonable but the execution of the assumption is incomplete. While the use of markers to delineate the footprint and the Withdrawal is acceptable, the peer review panel believes that technological advances (e.g., horizontal drilling) make it imperative that

the land outside the Withdrawal be considered in the development of passive institutional controls. Information stored in records centers and archives should also contain warnings relating to activities in the land beyond the Withdrawal.

4.2. General Technical Assumptions

The following discussion examines the assumptions used by the PTF to estimate the effectiveness of passive institutional controls in deterring future inadvertent human intrusions. The accuracy of these assumptions and the completeness of the set is critical in assessing the passive institutional controls. If the assumptions are incorrect or incomplete, the conclusions drawn from them will be invalid.

In general, the peer review panel found that the assumptions were correct but poorly supported in the document or by reference to other material. The panel felt that this section needed a great deal of "beefing up" to withstand challenge. (It should be noted that, in the comments that follow, Trauth et al. [1992] is referenced a number of times. Many of the assertions in Trauth et al. were based on other literature and information supplied to the expert panelists and the PTF. These resources are referenced in Section 9. Except where noted, this peer review report assumes that the way in which Trauth et al. used the supporting resources is appropriate.)

4.2.1. Assessment of Individual Assumptions

The following material reviews (in sequence) the subsections of Section 3, Assumptions Used in Estimating the Effectiveness of PICs in Deterring Future Inadvertent Human Intrusions (*PICs Efficacy Report* [pp. 3-1 to 3-7]).

Section 3.0 (Untitled introductory material)

The language of this section is unclear and its logical progression confusing. However, the peer review panel believes that the argument presented is as follows:

- There is no accepted methodology to make accurate long-term predictions of the future of mankind.
- DOE shall assume that all present-day conditions, with the exception of geologic, hydrologic, and climatic, will remain as they are today.
- The assumption that all present-day societal and demographic factors will remain constant is unacceptable.

The logical conclusion that the panel can draw from this is that the "conditions" referred to in the second bullet do not refer to present-day societal and demographic factors. The PTF concluded that those "conditions" referred to certain "societal 'common denominators'" or "patterns of human behavior that may be detected throughout history and around the world." This appears to be a reasonable conclusion based on the regulatory guidelines.

There now are six subsections to Section 3 of the *PICs Efficacy Report:* 3.1, Basic Human Attributes, 3.2, Government, 3.3, Language, 3.4, Natural Resources, 3.5, Estimating Passive Institutional Controls Effectiveness, and a Summary. If the purpose of Section 3 is to enumerate the assumptions defining these "societal common denominators," the peer review panel suggests the following structure:

- Basic Human Attributes
  - General
  - Society and Culture (Government)
  - Communications (Language)
- Natural Resources
- Summary

Many of the assumptions currently listed under Section 3.5, Estimating Passive Institutional Controls Effectiveness, actually are assumptions about human attributes. There are some basic assumptions about the human species that have been omitted entirely from the list; these could be included in a "General" section. The assumptions under Section 3.2, Government, are actually assumptions about the maintenance of social order. Government is but one institution or social mechanism for such maintenance. Section 3.3, Language, deals only with a small subsection of the communications process. For the sake of completeness, it should delineate broader assumptions about the process.

Section 3.1 Basic Human Attributes

Assumption 1: Curiosity of humans [will continue]. Although this is supported by the PTF through a simple reference to the CAG, the peer review panel could make a strong argument for this as a biological trait of the species and therefore one unlikely to change over the compliance period.

Assumption 2: The use of the written word to transmit information and concepts [will continue]. This assumption is supported only by reference to the CAG. The PTF may want to note that Trauth et al. (1992) (e.g., p. F-44) also supports this statement.

Assumption 3: Storytelling or the generational "passing down" of history [will continue]. This teaching/learning of abstract information is one of the distinguishing characteristics of culture and of

human beings. This assumption is a much more important part of this foundation of assumptions than is presented here. It needs to be supported in the document and not simply presented as an article of faith.

Assumption 4: The ability of pictures to convey meaning [will continue]. This also is strongly supported by Trauth et al. (1992) (e.g., pp. F-42ff) and should be indicated here.

Assumption 5: Some people will avoid, ignore, or be ignorant of government controls. This assumption actually incorporates two different types of assumptions that should be stated separately. To "avoid" or "ignore" governmental controls is a function of the psychological makeup of individuals and needs to be supported by reference to literature on rebellion and psychological dysfunctioning. To "be ignorant" of government controls is a function of the dissemination of information throughout a society. In large societies, this dissemination tends to be uneven: in small societies, information of this type is more likely to be known by all members. This assumption seems to state that the PTF assumes that the societies in place during the regulatory period will be large enough to promote uneven dissemination of certain types of information.

Assumption 6: Individuals will continue to look out for their own self-interests. This has been a statement of strong debate within the social science community (generally in the rhetoric of sociobiology) over many decades, and this debate has been expressed within the philosophical community for millennia. The PTF must be sure that it can, and is willing to, support this position.

Section 3.2 Government

Assumption 7: The existence of some form of government [is assumed]. This assumption would follow from the general species characteristic of sociability outlined at the beginning of this section. The PTF should be clear on what it means by "government," since this could easily be questioned. This definition also is important because the PTF considers "the government" to be the controlling institution for the archives and records, as well as other portions of the passive institutional controls. It also should be noted that the last sentence of the supporting language for this assumption could be seen as contradictory to Assumption 6 (i.e., "The 'individual' or 'group' in control makes decisions either for its own benefit or the benefit of the association" [emphasis added]). Can the governor (either group or individual) be altruistic?

Assumption 8: [Government will exert] some level of regulatory control. It is unclear how this adds to Assumption 7. This leads the peer review panel to ask again if the PTF can clearly define what it means by government. This is important to the effectiveness of passive institutional controls because it does

assume a supra-individual agent that might force the individual to act in a fashion that might appear to be counter to his or her self-interest. The definition of government and the way the government exerts its authority also depend heavily on assumptions about the nature of man. The PTF should be aware that there is literature and a scholarly tradition stretching back to the classical Greeks that address this question. It is a crucial question that underlies much of the philosophy and theory of our own governmental structures and actions.

Assumption 9: Governments will require and maintain records as part of the procedure to maintain controls. The peer review panel assumes that the PTF does not necessarily mean some kind of recording (which assumes a permanent means of marking), but rather the preservation of information that could also be accomplished through oral means. Also, this assumption builds on Assumptions 3, 7, and 8 and so may be termed a second-order assumption.

Assumption 10: Governments will continue to protect property rights. The PTF should document the assertions contained in the language supporting this assumption with reference to current and historic forms of governments that perform this function. This assumption could be more broadly stated as "society will continue to protect property rights" and government is one social mechanism that may perform that function. (This also depends upon how one defines "government.") The peer review panel also notes that, as with Assumption 9, this assumption builds on others given here (i.e., Assumptions 5, 6, 7, 8, and perhaps 9) and so may be termed a second-order assumption.

Section 3.3 Language

Assumption 11: Current English will continue to increase in the size of its vocabulary and the areas of use, but the basic vocabulary and structure will resist change. While this statement may be intuitively obvious, it should be supported by reference to scholarly work on linguistic evolution and change. This is particularly true of the second part of the sentence (the basic vocabulary and structure will resist change). Historical linguistics should be able to provide some evidence of probable rate of change. This would provide a basis for what are now unsupported statements in the document, such as the statement found in the *Conceptual Design Report* (p. 27) where the PTF states that "with the advent of printing and more recently the advancement of worldwide communication the rate of change of language has probably slowed considerably."

Assumption 12: Current English will remain decipherable by future generations of English readers for at least 1,000 years after disposal. This assumption is supported in the text by some references.

Additional references to the sections of Trauth et al. (1992) that discuss this issue would strengthen the argument.

Assumption 13: English will continue to be read by the natural-resources exploration and exploitation industries. This should be supported by reference to Trauth et al. (1992).

Section 3.4 Natural Resources

Assumption 14: Resource exploration and extraction will be conducted using drilling technology that is basically the same as today's. This assumption states that resource exploration and extraction technology will be essentially equivalent to that in current practice. Assumption 14 is clearly based on 40 CFR Part 194.33(c)(1) and is entirely consistent with this and other relevant regulations. DOE interprets Assumption 14 as conservative since a more developed technological society would also have better means of detecting the repository and radioactivity and would be less likely to inadvertently drill into the repository. A less-developed technological society would be less likely to have the means to drill into the repository.

It seems somewhat facetious to argue that the present represents a unique moment in history in which drilling rates are maximal. Analysis of drilling records contained in commercial oil and gas databases show that oil wells were drilled in the United States to below the proposed repository depth during the early decades of this century. This activity took place before methods for measuring gravity in oil were developed, such as the pendulum and the modern gravimeter that originated in the 1930s. Ground-based instruments to measure the magnetic field of rocks were introduced for mineral exploration in the 1920s and were used occasionally for oil exploration. For example, the Hobbs Field in Lea County, New Mexico, was discovered in 1927 based, in part, upon a magnetic survey of the area (Dobrin 1960, p. 318). Seismic reflection and refraction methods also originated largely in the late 1920s and early 1930s. These activities show that it was certainly technically possible to drill to repository depths although none of the standard exploration techniques of gravity, magnetic, and seismic reflection existed. Moreover, the regulatory environment in states like New Mexico or Texas at the beginning of the century exerted very little control over oil exploration and drilling. Prior to regulatory control, it was not uncommon for competing drillers to complete wells at a spatial density many times higher than is allowed under current regulations. This suggests that markers designed to be detected by geophysical methods may have less than a 1.0 probability of detection.

Assumption 15: Because of the uncertainties associated with predicting future natural resources, the historical drilling rates for oil and gas in the Delaware Basin are to be used in the PA as surrogates for future drilling rates for these unknown resources. The peer review panel believes this is a reasonable assumption, given that it is impossible to predict drilling practices for as yet unknown resources. The *PICs Efficacy Report* has adopted this assumption, which is entirely consistent with 40 CFR Part 194.33.

Assumption 16: There will always be natural resources of value within the Delaware Basin that will attract future exploration and support exploitation efforts. The *PICs Efficacy Report* adopts this assumption that is reasonable and consistent with 40 CFR Part 194.33.

Assumption 17: There will be virtually continuous natural-resource exploration and exploitation activities in the Delaware Basin during the entire regulatory time period. The *PICs Efficacy Report* correctly follows this assumption since drilling rates and densities are assumed to be constant over the regulatory period. While there might be some justification for arguing that exploitation of petroleum resources will diminish over the next several hundred years, the assumption of constant exploitation at current rates is consistent with 40 CFR Part 194.33 and is probably conservative.

Assumption 18: Resource exploration and exploitation is not a casual activity. This assumption is not required by 40 CFR Part 194, but is a logical assumption. The *PICs Efficacy Report* states that this assumption implies that those entities active in exploration and exploitation of natural resources will make an effort to access records. This follows logically and should enhance the performance of the records centers in preventing inadvertent intrusion.

Section 3.5 Estimating Passive Institutional Controls Effectiveness

Assumption 19: The determination of intrusion as inadvertent or intentional is not based solely on the actions of an individual but is also based on the actions of government in carrying out its responsibilities. As it is stated here, this is an incomplete assumption in the context of this exercise. "Inadvertent intrusion" is defined in this document as "any human activity that disrupts the disposal system" *(PICs Efficacy Report,* p. 2-7). The Markers and Futures panels defined "inadvertent intrusion" as occurring when "the integrity of a repository is unintentionally compromised by the activities of humans . . . " (e.g., Hora et al. 1991, p. I-1). The actions of a government may contribute to the lack of knowledge that would lead to such unintentional compromise, but such actions are only one among what may be many contributory factors. Therefore, to single out the government is correct, but incomplete. The panel believes that the discussion should include the possibility of other social institutions

performing the records maintenance, education, or other activities related to the prevention of inadvertent intrusion.

Assumption 20: Communicating with future societies using words, pictographs, symbols, and diagrams through a variety of media is possible. This assumption may be concluded from the work of the futures and Markers panels. It also may be deduced from an assumption regarding the unchanging biological nature of Homo sapiens over the compliance period and the continuing, associated ability of the species to engage in symbolic behavior. This assumption also embodies other assumptions about the ways in which Homo sapiens will internalize information from the physical environment (e.g., visually).

Assumption 21: Historical analogs of structures, media, and messages that have withstood the test of time allow the DOE to design for success. The Markers panel report spends a great deal of time discussing historical analogs. Both teams note that, while structures and media exist that have lasted for a time equal to approximately half the compliance period (about 5,000 years), we are less sure of the messages the artifacts were intended to convey (e.g., what is Stonehenge trying to tell us?). Therefore, while DOE probably can design structures and use media that will last for the compliance period, the evidence is not nearly as strong that it can develop messages that will continue to be comprehensible.

Assumption 22: Today's scientific and engineering communities have the capability to create PICs that will perform at least as effectively as historical analogs. While this is intuitively true, it should be supported with a statement or two about our enhanced knowledge of materials, structural design, and the like, instead of being presented as a statement of faith.

4.2.2. Completeness and Adequacy of Assumptions

This section discusses three aspects of "completeness." It begins with assumptions that are implicit in the list above, but that the peer review panel suggests be made explicit to ensure sufficiency of the assumption set. It then discusses two process models that underlie much of the work of the PTF and that the peer review panel believes should be made explicit to facilitate understanding and to explain the PTF's position on certain issues. Finally, the discussion addresses assumptions made by the expert panels that are incorporated into the PTF's work, but that are not made explicit.

Underlying the first three subsections of Section 3 (3.1, Basic Human Attributes, 3.2, Government, and 3.3, Language) are assumptions related to human evolution and associated human biological and social/cultural capabilities that are not made explicit. While these assumptions do not contradict or undermine the assumptions or the conclusions presented in this report (in fact they strengthen them), it is

necessary to state them because they underlie and support the assumptions presented in the document. Several assumptions that could be included in the PTF report to support their existing assumptions are described below.

Punctuated equilibrium is a theory of evolutionary development that postulates long periods of very slow change interrupted by short bursts of very rapid change. If one assumes an evolutionary paradigm of punctuated equilibrium and looks at the history and rate of change of human evolution, it would be reasonable to assume that Homo sapiens will exist over the entire compliance period of 10,000 years unless that period happened to include one of the major step changes that a punctuated equilibrium process includes. This is important for the following reasons:

- This assumes no significant major change in cranial capacity and associated cognitive capabilities, including information acquisition and processing.
- The ability to "symbol," one of the distinguishing features of Homo sapiens and a feature that underlies language and therefore much of culture, will continue.
- The social nature of the species will continue, leading to the conclusion that there will be some form of governance of the group as is the case for all social animals.
- Physical features that allow for the development of material culture, such as bipedal, upright locomotion and the opposable thumb, will continue to be displayed and will not change significantly.

In a related area, the peer review panel interprets the assumptions pertaining to the section on government as referring in a broader sense to "society," with government being one social institution by which the social control activities could be carried out. This allows non-secular institutions of social control, such as religion and other similar control institutions (e.g., kinship networks), to be introduced. This would have implications for continuity should there be profound social change in the society managing or controlling the site, archives, and/or records centers. Finally, the peer review panel believes that the section on language could be broadened to encompass "communication." This would allow for the inclusion of assumptions related to icons, indices, archetypes, and means of communication other than language upon which the success of the passive institutional controls might rely.

In its work, the PTF assumed but did not delineate some model of the communication process, either as an individual event or as a social activity. *Fundamentally, passive institutional controls are communication vehicles.* Therefore, inclusion of such a model is very important because it would demonstrate the relationship between data and information (i.e., data that has been "turned into" something meaningful), and between the existence of information and the way in which that information

is internalized to prevent intrusion. This relates to the understandability dimension, as distinct from the endurability component, of the passive institutional controls.

The communications process, shown in Figure 4.2.2-1, is usually diagrammed as follows:

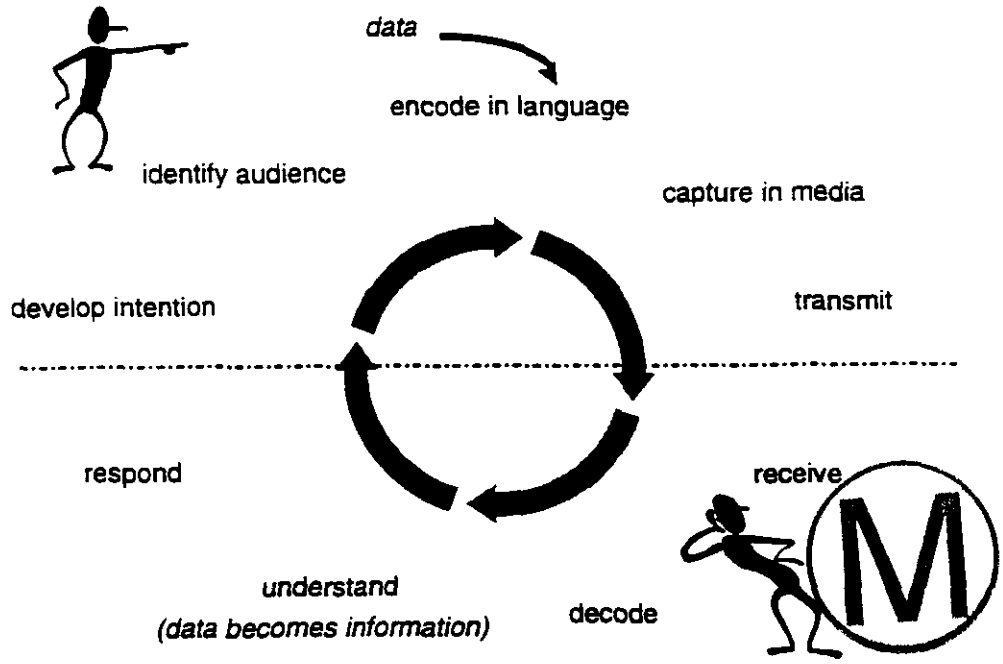


Figure 4.2.2-1. Standard communication model

This model is important because it can delineate some assumptions about the scope of the passive institutional controls. For example, will the effectiveness of the passive institutional controls be based on how well the data is captured in various media? (Some of the arguments advanced by EEG against potential effectiveness have to do with incorrect capture of data [Silva and Channell 1992].) Will the effectiveness of passive institutional controls be based upon whether the message is (a) received by an initial receiver or (b) received, correctly decoded, understood, and retransmitted (as might happen if there were more than one agency or institutional structure involved in the process)? Incorporation of a communication model could better demonstrate where and how passive institutional controls might fail.

The second process model, shown in Figure 4.2.2-2, is related. It describes the activities the PTF believes will occur for inadvertent intrusion to take place. It also describes the passive institutional controls associated with each activity that are designed to forestall such intrusion. The peer review panel developed this model from its readings and from information elicited from members of the PTF.

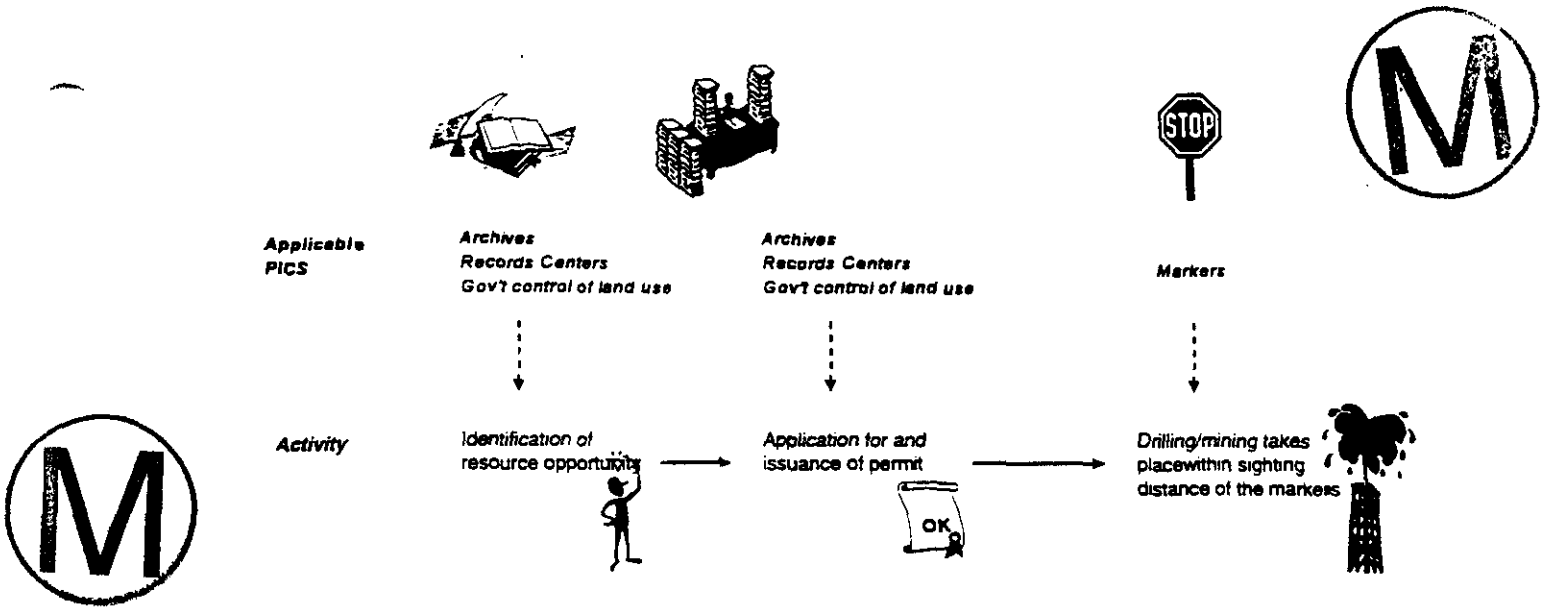


Figure 4.2.2-2. Model used by PTF as interpreted by the peer review panel

Figure 4.2.2-2 illustrates the association of specific passive institutional controls with different activities leading up to a possible inadvertent intrusion event. It should be noted that this model assumes that any inadvertent intrusion activity must encounter the markers and at least one of the other passive institutional controls.

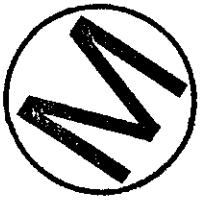
Team A of the PTF spent a great deal of time discussing archetypes and their importance in fulfilling the requirements of 40 CFR Part 194. This appears to underlie the design concept presented in the *Conceptual Design Report*. Therefore, the validity of archetypes should be stated as an assumption.

40 CFR Part 194.33 (b)(2) requires that drilling events be treated as random in space and time during the regulatory time frame of performance assessment. While the concept of "random" admits many interpretations, the *PICs Efficacy Report* clearly interprets this to mean that rates are uniform over the regulatory period and that drilling density is uniform in the Delaware Basin, including the Withdrawal area, with all areas having an equal probability of being drilled (e.g., *PICs Efficacy Report* Section 3-6, p. 3-7, and discussion of Assumption 17). A uniform distribution is one of many types of random distributions, but it is somewhat inconsistent with the idea of *random intervals* (40 CFR 194.33 (b)(2)). Random intervals imply non-constant intervals. An alternative interpretation would be that drilling events be treated as stochastic in space and time according to a Poisson process, which is commonly done in modeling other types of events for performance assessment calculations. This type of model also is consistent with the requirement that drilling events could occur at any time or place within the Delaware Basin with equal prior probability and constant mean density and mean rate of occurrence. The intervals in time or space are random, not constant. The difference is that in a Poisson process, only the mean rate

and density are constant. Other alternatives to uniform and Poisson processes are also possible that are consistent with the requirement in 40 CFR Part 194.33 to treat drilling events as random in space and time. In this respect, the *PICs Efficacy Report* does not adequately describe alternative models nor sufficiently defend the choice of the uniform model that has been adopted for performance assessment calculations.

4.3. Summary

The PTF interpretation of the applicable regulations is reasonable and adequate. The general technical assumptions presented by the PTF are correct but inadequately supported. References that could be used to support the assumptions are readily available; their use would make the assumptions more defensible and satisfy the requirements of the CAG. Additionally, the PTF assumptions could be further buttressed by including the assumptions stated above and by describing the conceptual communication and activity models assumed in the design concepts.



5.0 ADEQUACIES OF TECHNICAL PRESENTATION

5.1. Systems Approach

Section 4.1 of the *PICs Efficacy Report* (pp. 4-1 to 4-2) describes passive institutional controls as a system of deterrence components:

> . . . the DOE has extended the systems concept to incorporate archives, records, government land ownership and control, and other means of communication into the total PICs design (*PICs Efficacy Report*, p. 4-1).

The *PICs Efficacy Report* also makes three claims regarding this system:

1. Redundancy of individual components.
2. Sufficiency of each individual component to effectively deter inadvertent intrusion in the absence of any other component.
3. A "Gestaltic" nature, in which the system as a whole is more effective in deterring intrusion than the sum of its parts.

The *PICs Efficacy Report* states that this system contains redundancy in several forms that are described in Section 4.0 of the report (pp. 4-1 to 4-5). It is clear that the system of passive institutional controls proposed by DOE is redundant, as described in Section 4.0 of the *PICs Efficacy Report*.

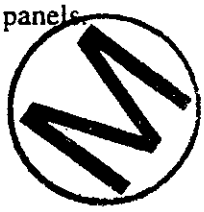
The peer review panel does not believe that the *PICs Efficacy Report* adequately substantiates the second claim regarding the sufficiency of each individual component of the passive institutional controls. A system consists of individual components, credible intrusion scenarios (or a series of activities associated with the intrusions), and a relation that describes the interaction between the deterrent components and the intrusion mechanisms. The *PICs Efficacy Report* does not describe such a system. This may be due to the fact that each component is assumed to sufficiently deter any inadvertent intrusion with zero failure rate. In this case, it would be pointless to diagram system interactions and components. However, the peer review panel does believe that the model of the "system" with which the PTF is working resembles the one presented in Figure 4.2.2-2, based upon conversations with a member of the PTF, K. Trauth (Trauth 1996).

Figure 4.2.2-2 illustrates an important point. The *PICs Efficacy Report* assumes that the marker component of the passive institutional controls is the last line of deterrence for all intrusion scenarios; therefore, the markers must be 100 percent reliable if the *system* is to be 100 percent reliable. If, for

some reason, the markers are not encountered by a particular credible intrusion scenario, or the markers do not have 100 percent reliability, the system cannot have 100 percent reliability. In the former case, the convolution of the individual reliabilities (or failure rates) for the archives, record centers, and governmental controls determines the overall system effectiveness. In the latter case, the system effectiveness is equal to the marker reliability.

The peer review panel believes that there are credible intrusion scenarios and marker failure scenarios that make both of these types of system failures possible (see Section 5.3). The panel thus believes that the *PICs Efficacy Report* has not sufficiently described or defended its particular system model and that the consequences of this particular passive institutional controls system model have not been adequately calculated for determining passive institutional controls credits.

In regard to the claim in the *PICs Efficacy Report* concerning the Gestaltic nature of the passive institutional controls system, the peer review panel finds little support in the document. There are two themes recurring in the *PICs Efficacy Report* and related documents that deal with systems. One concerns redundancy as a characteristic of certain kinds of systems; the other addresses a principle of systems, i.e., that the whole conveys more than each individual part and more than the sum of the parts (this is the idea behind Gestalt). A Gestalt implies nothing about redundancy; if the whole is greater than the sum of the parts, it does not follow that each part carries the message of the whole. The expert panels cited in Trauth et al. (1992, pp. F-28, G-34) strongly recommended adoption of the principle of Gestalt. The presentations in the *PICs Efficacy Report* and the *Conceptual Design Report* adopt the redundancy characteristic but do not adequately describe or defend the Gestaltic nature of the proposed system of passive institutional controls, despite the recommendations of expert panels.



5.2. Individual Components of the System

5.2.1. General Considerations

The regulations in 40 CFR Part 194 identify four different types of passive institutional controls: markers, records/archives, government ownership or control over land, and "other." By far, the bulk of the effort has focused on markers. There appears to have been little work invested in the last three types of passive institutional controls; no rationale has been given for the uneven effort. The PTF noted (in verbal communication with the peer review panel) that, since there is a large body of existing research and literature on archives and records, the PTF did not feel it necessary to create new information as it did with the Markers panels (Peer Review Panel Meeting, June 7, 1996). However, that literature is not

referenced in either of the two documents under review. Furthermore, the work cited by the PTF appears to have primarily addressed the Vatican archives, a repository maintained not by a government but by a religious institution (Peer Review Panel Meeting, June 7, 1996). While this does not negate its value for this project, none of the assumptions refer to any social institutions other than "government." It could be argued that religious institutions do constitute a form of government; however, the peer review panel can only assume that the PTF is referring to secular institutions of state government (where state refers to any political entity and could include a nation, a city, or some other secular jurisdiction), unless some definition of "government" is provided to allow the panel to assume otherwise. Therefore, for the PTF to make a legitimate extrapolation from the Vatican to secular government, some assumptions must be stated about the relationship between secular and religious institutions and their mechanisms of control over repositories such as those in question.

In the *PICs Efficacy Report*, the PTF states "the DOE has maintained the design considerations of the Markers panel recommendations while modifying the specific recommended designs in order to be practicable" (p. 5-1). The peer review panel emphasizes that the recommendations of the Markers panel were directed toward a markers system only, not to the other passive institutional controls identified in 40 CFR Part 191. How the design considerations were extended to the records and archives systems and to the government land-use controls is unclear in the documents under review.

The absence of a formal communication model leads to some questions about the scope of the passive institutional controls and the way the various elements of the system interact. Will the effectiveness of the passive institutional controls be based upon how well the data are captured in various media? (Some of the arguments advanced by EEG against potential effectiveness in EEG-50 have to do with incorrect capture of data [Silva and Channell 1992]). Will the effectiveness of passive institutional controls be based upon whether the message is received by an initial receiver, or received, correctly decoded, understood, and retransmitted (as might happen if there were more than one agency or institutional structure involved in the process)?

The *PICs Efficacy Report* states that the markers and records components are expected to survive with a probability of 1.0. The evidence presented for this probability is based on both historical analogs and an understanding of factors/processes that might degrade the markers or records over time. The panel believes that historical analog survival data must be used with care for the following reasons:

- We only have records about historical analogs that have survived. Analogs that did not survive are not observable. Thus, the survival of ancient analogs demonstrates that such man-

made structures can survive, but do not necessarily form the basis for calculating a failure rate.

- Processes that could have led to the destruction of the historical analogs in current-day society differ from the processes over the past 800 years. For example, the nose of the Sphinx survived for millennia until it was used for target practice. The ancient peoples in Egypt could not have vandalized the Sphinx as effectively. Thus, the survivability of some of the ancient analogs might have been reduced if present-day conditions had prevailed since their creation.

These potential pitfalls in using historical analogs to estimate failure probabilities for markers, records, etc., suggest that there should be some uncertainty associated with the durability/survivability of the passive institutional controls components. At the least, some evidence should be presented to show that the uncertainty is effectively 0.0.

5.2.2. Markers

Permanent markers consist of five distinct components: the berm, surface monuments, the information center, buried storage rooms, and small buried markers. The criteria used to conceptually design each of these components is described in the *PICs Efficacy Report* and the *Conceptual Design Report*. 40 CFR Part 194.43 requires DOE to demonstrate that there is a reasonable expectation that these markers will endure for the several-hundred-year period following repository closure in order to receive credit for performance assessment. As different materials and designs are envisioned in the *PICs Efficacy Report* for the five marker components, each is evaluated separately.

5.2.2.1. Durability

Berms

Trauth et al. (1992) have considered several issues in creating a berm surrounding the disposal area footprint. The berm would be based upon sound engineering considerations. These are summarized in Section III of the *Conceptual Design Report*. The PTF has considered three classes of failure mechanisms: erosion, burial by dunes, and deliberate removal through vandalism or mining. These mechanisms seem to be the only plausible means by which the berms could be threatened during the regulatory period. The peer review panel finds that the design solutions suggested in the *Conceptual Design Report* and the *PICs Efficacy Report* (Section 5.2.1.5, p. 5-6) provide reasonable assurance that these potential failure mechanisms can be mitigated. The panel believes that there is a very high probability that the berms, as described, will survive throughout the 700-year period following closure. The panel concludes that it is reasonable to use a failure probability with regard to durability of 0.0, but

that the failure probability should have some very low value of uncertainty. However, Section 6.2 of the *PICs Efficacy Report* (p. 6-9) states "the PTF has taken no credit for these components in the effectiveness estimates" for determining credits for passive institutional controls, so the credit issue may be moot.

Surface Monuments And Information Room

The choice of materials and the design of the surface monuments and the information room are described in Sections 5.2.2 and 5.2.3 of the *PICs Efficacy Report* (pp. 5-6 to 5-14). Six potential failure mechanisms have been considered. The PTF has addressed each of these potential failure mechanisms from the standpoints of durability and survivability. The peer review panel believes that the choice of granite is well-founded from a historical perspective, from the standpoint of practicality, and from evidence that granite will provide a very durable material due to its physical and chemical properties. The physical and chemical basis for assuming that granite will resist weathering more than 700 years is well described in Trauth et al. (1992), Appendix G. The panel concludes that weathering and erosion are unlikely to cause the failure of the marker system and that a mean failure rate of 0.0 with small uncertainty is justifiable for performance assessment credit calculations.

The panel also concurs that the failure rate due to dune burial, museum removal, and recycling has been successfully mitigated by various features in the conceptual design, and could reasonably be expected to have a very low (perhaps 0.0) failure rate with low uncertainty.

Of the other possible failure mechanisms, the panel believes that defacement through vandalism, souvenir hunting, and destruction poses the greatest threat, and that the failure rate of 0.0 for these scenarios has not been justified.

Section 5.2.2.6 of the *PICs Efficacy Report* does not discuss situations in which massive destruction of structures has occurred (pp. 5-9 to 1-10). For example, many structures with far more durable materials, size, government control, etc., have been obliterated by bombing campaigns during times of war or during weapons testing. Various military targets exist in the vicinity of WIPP; it is possible that the surface marker facilities could suffer collateral or intentional damage. Vandals in urban areas of the United States have destroyed or defaced entire buildings. Moreover, souvenir hunters have dismantled and carted off paintings and pieces of many ancient buildings throughout the world, in spite of active governmental controls specifically put in place to prevent this type of vandalism. The report has failed to adequately address the extent of damage that historical or present-day vandalism has wrought upon

markers, monuments, and surface structures. As a consequence, the panel believes that a failure rate of near 0.0 has not been justified by evidence presented in the *PICs Efficacy Report* or in the *Conceptual Design* Report for either surface markers or the information center.

Buried Storage Rooms

The two buried storage rooms will be constructed of granite. In general, the durability issues and conclusions germane to the surface markers and information center pertain to the subsurface rooms, with a few modifications. First, surface weathering, erosion, and dune migration are of less consequence since the potential for surface processes is reduced, even if the buried rooms are partially uncovered at some future date. Likewise, defacement due to vandalism, souvenir hunting, or war-related damage is probably reduced since burial offers additional protection from these failure mechanisms. As in the case of the surface components, these buried components may still face non-zero failure rates due to war, vandalism, or souvenir hunting. The panel does not believe that a 0.0 failure rate for the buried rooms has been justified in the reports under consideration.

Small Buried Markers

The small buried markers consist of slabs that are approximately 1 foot (ft) in dimension. They are to be buried randomly at depths ranging from 2 to 6 ft and spaced so that the markers will be within 15 to 40 ft of one another. They are to be made of granite, aluminum oxide (sapphire), or fired clay (*PICs Efficacy Report*, Section 5.2.5.1, p. 5-19). The primary purpose of these markers is for them to be encountered during the preparation of a site for drilling operations. The *PICs Efficacy Report* cites four possible failure mechanisms: weathering, previous excavation, museum removal, and recycling removal (Section 5.2.5.6, p. 5-20).

In Trauth et al. (1992, pp. F105-F107), Team A presents reasonable evidence that these materials have survived and should survive for periods longer than the regulatory time frame in the face of weathering or erosion. The panel also believes that the design solutions described in Section 5.2.5.6 of the *PICs Efficacy Report* can ensure that at least some of the buried markers survive throughout the regulatory period (p. 5-20). However, if some of the markers are removed for recycling or other purposes, and nothing is put in their place, then the 100 percent detectability during a standard drill pad preparation operation would be reduced since there may be "holes" left that are now large enough to accommodate the drilling operation. The *PICs Efficacy Report* should address how gaps left by marker removal will affect the probability that a small buried marker will be encountered during an inadvertent drilling operation.

5.2.2.2. Comprehension

Design and Comprehension

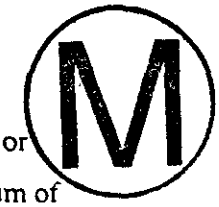
The PTF provides a reasonable discussion of the way in which the components of the markers system are expected to interact to convey a comprehensible message. The peer review panel believes that the assumptions outlined in Section 3.0 of the *PICs Efficacy Report* (pp. 3-1 to 3-7) and the historical analogs provided in Section 5.0 (pp. 5-1 to 5-32) would reasonably indicate that there is a high probability the messages will be comprehensible over the approximately 700 years of the compliance period. The panel believes that the PTF has legitimately demonstrated how it will address the various aspects of the communication model present in Figure 4.2.2-1 of this report. However, the peer review panel also believes that there is some significant, albeit low, level of uncertainty that should be assigned to this probability (i.e., uncertainty is not 0.0) due to the reasons discussed below.

Team A provided its marker system as an example of the way the concepts and principles it recommended could be put into operation. It did not provide a specific recommendation for a particular design, but rather a set of design guidelines (Trauth et al. 1992, p. F-49ff), suggesting that there are many possible ways these guidelines could be put into operation. This put a burden on the PTF to demonstrate how the design it developed addressed the performance-based guidelines. While the *Conceptual Design Report* did include most of these guidelines in its design criteria, it missed a few important ones (e.g., that the center should be a non-place and that regular, geometric forms are to be avoided). Furthermore, the *Conceptual Design Report* used the example of the system presented by Team A to illustrate its principles as the design put forward by Team A. The peer review panel believes this impoverishes the work presented by Team A by reducing its principles to a recommended design; uses its example design inappropriately; and does not recognize the uncertainty associated with the selection of this one possible example from the many possible examples Team A could have used.

Team A "recommends the use of vertical masonry markers, if their form feels dangerous, more like jagged teeth and thorns than ideals embodied" (Trauth et al. 1992, p. F-41). This also is reinforced later in the document when it is stated that "Design of the entire site and its subelements should *avoid those forms* that humans regularly tend to use to represent the 'ideal,' 'perfection,' or 'aspiration.' Ideal and perfect ones are the perfect forms of symmetrical geometry and of regular crystalline structures" (Trauth et al. 1992, p. F-52, emphasis in original). Team A reiterates this theme when it says to "Note our use of *irregular geometries and the denial of craftsmanship*" (Trauth et al. 1992, p. F-59, emphasis in original). Team A also strongly recommends an empty center, noting that "making a center . . . is the first act of

marking order (Cosmos) out of undifferentiation (Chaos). All further meanings of 'center' derive from this original positive valence . . . . In this project, we want to invert this symbolic meaning . . . we suggest that the largest portion of the Keep, its center, be left *open* . . . so that symbolically it is: uninhabited, shunned, a void, a hole, a non-place" (Trauth et al. 1992, p. F-52, emphasis in original).

Team B proposed a more geometrically regular design, including a focused center, but did not give the same level of defense of such regularity as Team A did of its counterproposal. The design developed in the *Conceptual Design Report* adopts the principle of regularity and of a strong center, but does not give a rationale for adopting this course rather than the other. Again, this suggests the possibility of alternatives to the design the PTF is proposing and introduces uncertainty.



Both expert panels that addressed developing a marker system emphasized the Gestalt/systems or "whole" nature of the markers as a communication vehicle. Team A suggested that "our medium of communication is the entire environment experienced near and at the WIPP site" (Trauth et al. 1992, p. F-28). Team B suggested that ". . . the probabilities and performance characteristics proposed above for the individual markers would be greatly enhanced by their inclusion within a larger, well-integrated marking system" (Trauth et al. 1992, p. G-34). The peer review panel does not see evidence that the PTF incorporated this principle of systems into its proposed design (see Section 5.2.1 for further discussion).

Human error and variability among individuals must not be ignored. While curiosity is indeed a species characteristic (Assumption 1), this statement is a relative one (Homo sapiens exhibits more curiosity than other species) and some individuals are more curious than others. It is possible that the individuals assigned to visit a field site for a drilling/mining activity may encounter the markers but may not be motivated enough to investigate (see Trauth 1993, p. F-139ff). A more detailed psychosocial profile of the species may indicate the uncertainty that needs to be associated with this. The possibility of human error either in encoding or decoding the message is illustrated in the *Conceptual Design Report*, which gives sample text for the messages on the monuments. The text states that "The waste is buried 655 kilometers deep" (p. 123). While the probabilities of such error may be small, they do exist. Both these points (i.e., the variability of curiosity level between species members and human error) introduce uncertainty into the calculation.

Communication Vehicles

Both Markers panels suggested that the development and adoption of an international symbol to identify the sites is a critical part of making a markers system effective (Trauth et al. 1992, pp. F-25, G-46).

There is no effort to do this in DOE's proposed conceptual design for passive institutional controls. In fact, the *Conceptual Design Report* simply says "No international standards exist. If, in the future, standards are developed and adopted by the United States, they will be evaluated for incorporation as appropriate in preparing the final permanent marker design" (p.17). Since both teams felt that such an international standard is a very important part of the effectiveness of the markers system, the peer review panel believes that the conceptual design should include a proposal to develop such a standard, especially since the absence of such a standard will increase the uncertainty associated with any design.

Both Markers panels suggest using the languages of the United Nations as the languages of inscription. The peer review panel believes that the United Nations languages were chosen by the United Nations founders for political reasons, not for reasons germane to a long-lived markers system. While some of the languages chosen fit both rationales, others may not. The panel believes that this is an incorrect criterion for language selection for this project and contributes to the uncertainty factor.

Team A suggested Navajo as the seventh language for the on-site system, Team B suggested Mescalero Apache. Navajo was adopted into the conceptual design by the PTF with no accompanying justification for why it, rather than Apache, was adopted.

Testing

Both Markers panels suggest testing elements of the proposed system on extant populations, controlling for variables such as levels of technology development, race, sex, and culture (Trauth et al. 1992, pp. F-46, G-73ff). There is a section entitled "Testing" in the *Conceptual Design Report* (pp. 74-77). In this section, only one paragraph is devoted to testing for comprehensibility; the remainder of the section is devoted to testing for durability. The descriptions of the comprehensibility tests are cursory and incomplete. References to those tests are missing from the *PICs Efficacy Report*.

5.2.2.3. Summary

Based upon the assumptions and the work done by the Markers panels and others, the peer review panel believes that individual components of the design probably will work. However, the entire design could be made stronger by incorporating the Gestalt/systems principle and by developing and testing some of the communication vehicles. Such development and test programs should be part of the conceptual design. The peer review panel believes that the probability that the messages captured in the markers will be understood is very high but also believes that there is some uncertainty associated with that probability.

5.2.3. *Archives*

5.2.3.1. Durability

The *PICs Efficacy Report* states that "The initial form of the information will be archival-quality paper" (Section 5.3.1, pp. 5-20 to 5-22). The location of these archives has not been established, but the *PICs Efficacy Report* suggests several possible candidates. Two classes of failure mechanisms were assessed: (1) durability of the archival material and (2) survivability of the archive.

Decay of the paper or degradation of the ink would be addressed by using archival paper, carbon black ink, and controlled storage environments. These design solutions could be reasonably expected to ensure that the archived material will not succumb to normal aging with a failure rate close to 0.0.

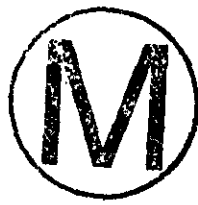
The other failure mechanisms describe threats to the archived materials' survival. These include theft, misfiling, natural disasters, recycling, inadvertent disposal, loss, or deliberate destruction. Virtually any large organization archives written records; it is a common experience that archived records disappear after a few decades (or less) despite the fact that these records may have significant financial value to the organization. Neither the *PICs Efficacy Report* nor the *Conceptual Design Report* present evidence for the survival rate of archived material, although institutions such as the Library of Congress could provide such data. The examples of archives that have survived, as mentioned in Section 5.2.1, only demonstrates that archives can survive and cannot be used to estimate failure rates. For this reason, the peer review panel does not believe that a failure rate of 0.0 for archive durability has been justified in the documents under review.

5.2.3.2. Comprehension

The discussion on comprehensibility of the archives assumes the information is captured in some document and is in a repository. However, the peer review panel believes that a successful communication event (i.e., one in which the intention of the speaker is captured and "understood" by the listener) depends upon successful execution of all steps in the communication process (see Figure 4.2.2-1). This includes appropriate encoding in language (i.e., capturing the necessary data in appropriate language and form), capturing in media (i.e., inscribing using appropriate materials), and transmitting (i.e., actually getting the documents from the creators to the appropriate archives). The peer review panel believes that the PTF did not adequately address these steps.

In the *Conceptual Design Report*, the PTF states that "the DOE will develop a WIPP summary document" (p. 92). How will its contents be determined? For example, why was so much effort put into

developing a prototype of a level IV message for the markers system when no sample table of contents for this document was presented? Who will request archives to locate and catalog that volume? (The sentences in the reports under review which describe these activities are written in the passive voice and, hence, the agency is unclear.) Is a request from that source likely to be heeded? In what language(s) will these documents be written?



The *Conceptual Design Report* gives a list of documents recommended for inclusion in the archived information portfolio (p. 93). What is the logic that drove the creation of this list? What were the criteria for selection?

The *Conceptual Design Report* states that "the most likely strategy for long term protection of the information is through widespread distribution" (p. 94). How is "widespread" defined? Geographically? Functionally? Politically? For example, would it be safer to have a copy stored in a church repository in Monterrey, Mexico, or one in a laboratory archive at Brookhaven National Laboratory? As a related question, what is the logic behind the list of archives presented immediately following?

The *Conceptual Design Report* also states that the "DOE archivist will develop a filing code system specifically for the WIPP material" (p. 94). How will this system speak to cultural logics of which we know little or nothing? How will it be developed?

The *Conceptual Design Report* further states that "each volume containing documents will be labeled with a warning that the intent of providing the archived material is to ensure its preservation for the 10,000 year regulatory time frame stipulated in the United States Government's regulations controlling the disposal of Transuranic Waste" (p. 94). Is it not the intent of the archived material to provide an "awareness trigger" (see comments re: Section 5.4) to alert the reader that he or she needs to be educated as to what is going on at the site and not to "ensure its [the archived material's] preservation . . . ?"

5.2.3.3. Summary

The primary concerns of the peer review panel with this portion of the conceptual design are: (1) what gets into the archives and (2) how it gets there. Because this part of the communication process is inadequately explained by the PTF, the peer review panel believes that the probability of a successful communication event is low and the uncertainty is high. The peer review panel does note that it is possible to increase this probability and decrease the uncertainty by developing arguments based upon the assumptions in Section 3.0 of the *PICs Efficacy Report* and by using other readily available materials.

5.2.4. Records

5.2.4.1. Durability

The issues that pertain to the durability/physical survival of the archived materials are essentially the same for the records. The difference is that the survival probabilities considered reasonable for the archives should be less for the records since "Record centers . . . would generally permit freer access by members of the public and do not normally exercise the degree of environmental control and information-medium selection to be found in modern archives" (*PICs Efficacy Report*, Section 5.4.1, pp. 5-25 to 5-27). The peer review panel believes that a failure probability of 0.0 with little or no uncertainty has not been substantiated by the reports under review.

5.2.4.2. Comprehension

As with the archives, the peer review panel believes that the records centers were given extremely short shrift, particularly given the process model in Figure 4.2.2-2 and the associated argument we present that underscores that the records centers and archives may have to serve as the only deterrent. This criticism is bolstered by the PTF's adoption of the redundancy or "defense-in-depth" approach.

The comments made in Section 5.2.3 (Archives) regarding the accurate capture of appropriate information into a document and the placing of that document in a repository also pertain to the records center. In addition, the comments regarding a summary document and an admonitory label on the cover relative to the archives are relevant here.

The *Conceptual Design Report* gives a list of recommended records centers (p. 95). What is the logic that drove the creation of this list? What were the criteria for selection? The list is introduced by the statement ". . . these Federal and State Libraries/agencies include:" Are there others?

5.2.4.3. Summary

The peer review panel's assessment of the records center is the same as its assessment of the archives. The primary concerns consider what gets into the records centers and how it gets there. Because this part of the communication process is inadequately explained by the PTF, the peer review panel believes that the probability of a successful communication event is low and the uncertainty is high. The peer review panel does note that it is possible to increase this probability and decrease the uncertainty by developing arguments based upon the assumptions in Section 3.0 of the *PICs Efficacy Report* and by using other readily available materials.

5.2.5. Government Land-Use Control

5.2.5.1. Durability

There are no durability issues concerned with government land-use control.

5.2.5.2. Comprehension

The *Conceptual Design Report* and the *PICs Efficacy Report* discuss current land-use controls through government ownership. They make no mention of, or reference to, how these controls will continue beyond the lifetime of existing institutions. The peer review panel believes that the PTF should use the assumptions presented in Section 3.0 of the *PICs Efficacy Report* and other material, as appropriate, to develop reasonable and defensible projections (pp. 3-1 to 3-7).

5.2.5.3. Summary

The PTF has provided no information in either the *PICs Efficacy Report* or the *Conceptual Design Report* to indicate how government land-use controls will continue as a deterrent or awareness trigger over the 700 years in question.

5.2.6. Other Passive Institutional Controls

5.2.6.1. Durability

There are no durability issues related to the "awareness triggers" described in Section 5.6 of the *PICs Efficacy Report* (pp. 5-30 to 5-31).

5.2.6.2. Comprehension

What is the logic behind the list of cartographic and geographic organizations that will receive location and hazards information for mapping purposes (*Conceptual Design Report*, p. 97)? How will this list be developed? Who will develop it?

What is the logic behind the identification of "companies providing energy and resource-related data to commercial ventures . . ." that receive location and hazards information (*Conceptual Design Report*, p. 97)?

Is the list of other passive institutional controls given in the *Conceptual Design Report* (pp. 99 to 100) an inclusive one? How will these controls be handled?

5.3. Completeness of Failure Scenarios

In general, the *PICs Efficacy Report* presents a wide-ranging review of possible failure mechanisms for the passive institutional controls components and addresses these problems through credible and practical design solutions.

5.3.1. Horizontal Drilling

The peer review panel believes that failure due to horizontal drilling from outside the Withdrawal area has not been adequately discussed and constitutes a credible scenario for inadvertent intrusion. Current technology for drilling horizontal wells would make it possible to drill a horizontal lateral from outside the Withdrawal into the repository. Horizontal well drilling technology is rapidly advancing and it is not unreasonable that the current length of horizontal wells will increase by thousands of feet within 1 to 2 years. Team A in Trauth et al. (1992, p. F-108) indicated that protecting against even a 15-degree slant hole would require marking 2 miles beyond the footprint of the waste panels, which includes areas outside of the Withdrawal. However, the current system of passive institutional controls, as described in the *PICs Efficacy Report* and *Conceptual Design Report*, does not describe a marking system outside of the Withdrawal area.

This credible failure scenario is particularly important since the surface or buried monument system does not necessarily deter this type of intrusion. Section 4.1 of the *PICs Efficacy Report* assumes that the proposed passive institutional controls constitute an integrated, redundant system of components (pp. 4-1 to 4-2). This means that "the effectiveness of the PICs system . . . will remain high even if the effectiveness of individual components is compromised by some failure mechanism." The *PICs Efficacy Report* also states that "potential future intruders should be effectively deterred from drilling into the Withdrawal as long as one of these component remains sufficiently intact to provide a warning" (Section 4.4, pp. 4-4 to 4-5).

These statements suggest that any of the four defined passive institutional controls components—markers, record centers, archives, and government control of land-use—are sufficient to deter intrusion without help from other components. The deterrence would need to come from record centers and government control of land-use. However, the *PICs Efficacy Report* implies that the survival of only the marker components would be an effective deterrent to horizontal drilling. It is not clear that the reports under review have justified this implication.

5.3.2. Collateral Damage Due to War

The *PICs Efficacy Report* does not discuss situations in which massive destruction of surface or subsurface monuments has occurred due to war-related activities. For example, many structures larger than the proposed markers at WIPP, constructed of far more durable materials, and protected by very active government controls, have been obliterated by bombing campaigns or artillery fire. War is discussed in the context of the historical survival of archives and records centers in the *PICs Efficacy Report* but, for unknown reasons, is not discussed as a potential failure mechanism of the markers.

A credible failure scenario for the surface and subsurface marker system is important since the loss of this system would dramatically increase the likelihood of inadvertent drilling and mining and would imply that the failure rate of the permitting process for mineral extraction would govern the probability of intrusion.

5.4. Credit Calculations

5.4.1. Regulatory Standard

As stated in 40 CFR Part 194.43(3)(c), credit to reduce inadvertent drilling and mining intrusions may be granted if the applicant can justify that passive institutional controls "are expected to endure and be understood by potential intruders for a time period approved by the Administrator." The CAG states that this justification should "require a deterministic analysis, based on scientific data." The peer review panel interprets this to mean that the credit should be expressed quantitatively and that its calculation should be an obvious and defensible logical progression from scientific observations. The panel is concerned that the method of credit calculation is inconsistent with passive institutional controls system presented in the *PICs Efficacy Report* and is inadequate for the purposes of 40 CFR Part 194.43.

5.4.2. Inadequacy/Inconsistency of Calculation Methodology

The *PICs Efficacy Report* claims that the proposed passive institutional controls constitute a redundant system to prevent inadvertent intrusion. A system is made up of components. In this case, the system has several identifiable components such as the surface markers, the berm, the subsurface markers, the archives, and the records centers. It is common practice to estimate the probability of system failure from the reliability (or failure rate) of the constituent components, as is done for the Combined Cumulative Distribution Function performance assessment of the WIPP project at a much higher level of aggregation. This requires a numerical estimate of the failure rate of each component, uncertainty

surrounding this value, and a structure that captures how the various failure mechanisms interact with the passive institutional controls components that have been emplaced to deter them.

The *PICs Efficacy Report* does not follow this method in assessing the reliability of passive institutional controls to prevent inadvertent intrusion (or tacitly assumes that their failure rate is 0.0 with no uncertainty). No numerical values for individual components are provided, nor are uncertainties, with the sole exception of inadvertent drilling rig mislocation. This is probably because the report concludes that the failure rate for each of the passive institutional controls components is 0.0 with no uncertainty in this value. Likewise, there is no discussion of how the failure mechanisms interact with the passive institutional controls deterrents. As discussed in Section 5.3, the prevention of credible intrusion scenarios (such as horizontal drilling) requires the survival of records and governmental control of land-use. It is debatable that the survival of subsurface markers will have any deterrent effect. Thus, the estimate of the credit given to passive institutional controls should be based upon the estimates of the failure rates of each component and how they interact with each other and the intrusion scenarios.

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5.4.3. Consequences for Performance Assessment Calculations

Uncertainty for reliability or failure for any of the passive institutional controls components was scarcely addressed in the *PICs Efficacy Report.* In Section 5.0, which discusses the failure of the constituent components, failure rates are not calculated (*PICs Efficacy Report,* pp. 5-1 to 5-32). However, the discussion in Section 6.4 implies that the failure rates are 0.0 since the only possible failure mechanism discussed with regard to performance assessment is inadvertent mislocation of drilling rigs (*PICs Efficacy Report,* pp. 6-10 to 6-11). The report indicates that there is no uncertainty in the 0.0 failure rate for the markers, records, archives, and government land-use control systems and indicates that the comprehension probability for all passive institutional controls is extremely high. The peer review panel finds that this high level of probability and confidence has not been substantiated by the discussion in the *PICs Efficacy Report* or in its supporting documentation.

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Discussions with Peter Swift of SNL (Swift 1996) were held concerning the sensitivity of performance assessment calculations to drilling rates. Swift indicated that the calculations of release were very sensitive to drilling rates, something on the order of a linear scaling in which doubling the drilling rate doubles the release. Thus, the amount of credit given to the passive institutional controls is very important for performance assessment, which implies the consequences of any uncertainty surrounding the passive institutional controls credit may be very significant.

The peer review panel did not find that the *PICs Efficacy Report* adequately discussed the uncertainty surrounding failure rates for passive institutional controls components, given the significant consequences on the calculated releases if the assumed failure rates are wrong.

Uncertainty is discussed for the inadvertent mislocation of drilling rigs in Section 6.4 of the *PICs Efficacy Report* (pp. 6-10 to 6-11). A bounding value of 0.01 for failure is assumed. The derivation of this number is not based on any calculation but is felt to be highly conservative since it is several orders of magnitude greater than the historical drilling. Credible estimates of mislocated drilling operations in Texas and New Mexico suggest that the mislocation rate was on the order of 1 in 100,000 or less. However, the panel finds that there are other credible failure scenarios whose rate may be higher but that are not addressed in the present reports. Moreover, the failure rates for the passive institutional controls components are assumed to be 0.0 and, with the exception of mislocated drilling operations, have an uncertainty of 0.0. The panel does not believe that the 0.0 failure rate or the 0.0 level of uncertainty has been substantiated in many of the failure scenarios, as described in Section 5 of this report.

The peer review panel also believes that the credit for the passive institutional controls should be calculated using a systems approach in which the failure rates and their uncertainties are aggregated into a cumulative probability distribution. The mathematical model for the system, which consists of the failure probabilities for each passive institutional controls component and its relation to all identified credible intrusion scenarios, should match the system implied in the reviewed reports.

6.0 CONCLUSIONS

The following conclusions regarding the calculation of the credit for passive institutional controls were given in the *PICs Efficacy Report;* the panel's comments follow each conclusion.

1. This report concludes that the sole cause of failure is incorrect location of a drilling rig. The panel believes that there are other failure scenarios that have not been taken into account—specifically, horizontal drilling, collateral damage due to war, and vandalism.

2. The effectiveness of the deterrence afforded by the passive institutional controls components is such that any component, in isolation from all other components, effectively deters inadvertent intrusion. This conclusion ignores the systems nature of the passive institutional controls in that, despite all of the system redundancy, some components do not have the same level of deterrent efficacy as others for every credible intrusion scenario.

3. The report describes historical analogs for the passive institutional controls in order to justify a 0.0 failure rate for durability. However, failure rates ascribed on the basis of historical analogs do not account for the fact that similar monuments or constructions have not survived.

4. The report concludes that vandalism and souvenir hunting will be effectively defeated by the passive institutional controls design. The panel believes that this conclusion has not considered the historical destruction of similar types of monuments, markers, and constructions during periods of war or loss of active governmental control.

5. The report concludes that the marker system is 100 percent reliable with no uncertainty, and that the records/archives/land-use controls are highly reliable with no uncertainty. The panel believes that there is uncertainty attached to comprehension of all the passive institutional controls and that the records centers and archives, as described in the documents under review, are highly likely to fail as communication events.

7.0 SIGNATURES

I, by signature, acknowledge that I concur with the findings and conclusions of this Passive Institutional Controls Peer Review Report.

Jessica Glicken, Ph.D.
PICs Panel Chairman

Elizabeth Hocking, J.D.
PICs Panel Member

Paul La Pointe, Ph.D.
PICs Panel Member

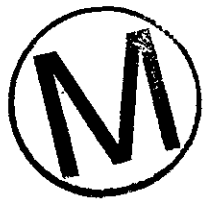
8.0 PEER REVIEW MEMBERS AND ACCEPTABILITY

Jessica Glicken, Panel Chairman, is a Senior Anthropologist with ecological planning and toxicology, inc. (ep&t) in Albuquerque, New Mexico. She has a Ph.D. in anthropology from Cornell University with a geographic specialty in Southeast Asian studies and a theoretical specialty in cultural linguistics and symbolic anthropology. She holds two master's degrees, one in Cultural Anthropology from Cornell University and one in Social Anthropology from the University of Michigan. Dr. Glicken has over 14 years of experience in communications, strategic and organizational development and management, and policy analysis. She develops communication strategies for both public- and private-sector clients, which includes identifying stakeholder groups; developing, implementing, and analyzing communication vehicles; and analyzing responses. Dr. Glicken is an experienced policy analyst in national and international energy and sustainable development programs, and has worked extensively on government and organizational structure and management. Dr. Glicken has published and given presentations on public participation, decision analysis, energy policy (foreign and domestic), and intelligence strategies.

Elizabeth K. Hocking, Panel Member, is a Legislative Analyst and Section Manager with Argonne National Laboratory, based in Washington, D.C. She holds a J.D. from the Washington College of Law at American University. Ms. Hocking provides technical, legal, and programmatic analyses of current statutes, regulations, and judicial decisions affecting DOE and the energy industry. Ms. Hocking's work in the area of passive institutional controls has included the identification and analysis of salient legal (statutory, regulatory, and common law), policy, and practical issues related to the use of institutional controls on real property owned and transferred by the DOE. She has also investigated the limitations, implementability, enforceability, and fairness of reliance on institutional controls, providing support to DOE in its decision-making regarding the use of passive institutional controls. Her publications and conference presentations have focused on recycling, pollution prevention, and federal facility compliance under the Resource Conservation and Recovery Act.

Paul R. La Pointe, Panel Member, is a Mathematical Geologist, Rock Mechanics Engineer, and Associate with Golder Associates in Redmond, Washington. He has a Ph.D. in mining engineering and an M.S. in geology, both from the University of Wisconsin. Dr. La Pointe has more than 16 years of experience in the oil and gas, mining, and natural resource development industries. He is currently responsible for management and technical direction of reservoir engineering and characterization projects for domestic and international petroleum companies. His projects have included geological analysis, reservoir characterization, and flow simulation for fractured reservoirs in the United States,

Canada, and Europe. He has served as an expert advisor to the U.S. Geological Survey to review methodology for the 1995 National Petroleum Resource Assessment. Dr. La Pointe has also performed technical analyses for a variety of hazardous and nuclear waste-related projects in the United States and abroad. Flow-through rock fracture systems are a prominent concern in these projects. Dr. La Pointe has conducted several workshops and short courses for professional geological societies and private companies in the petroleum and nuclear waste industries. He has authored or co-authored numerous papers and three books on the mathematical characterization of geological systems. Dr. LaPointe has served as an editor of the International Journal of Rock Mechanics and Mining Sciences since 1983.



9.0 REFERENCES

Berry, W.E. 1983. *Durability of Marker Materials for Nuclear Waste Isolation Sites.* ONWI-474. Columbus, OH: Battelle Memorial Institute.

Dobrin, M.B. 1960. *Introduction to Geophysical Prospecting.* Second Edition. New York: McGraw-Hill Book Co.

Environmental Evaluation Group. *Compilation of correspondence between EEG and DOE regarding mineral leases and drilling activity in the vicinity of the WIPP.* Binder prepared by EEG for Passive Institutional Controls Panel. Cover letter dated June 11, 1996.

Givens, D.B. 1982. "From Here to Eternity: Communicating with the Distant Future." Et cetera, pp. 159-179.

Goad, D. 1979. *A Compilation of Site Selection Criteria Considerations and Concerns Appearing in the Literature on the Deep Disposal of Radioactive Wastes.* EEG-1. Albuquerque, NM: Environmental Evaluation Group.

Guzowski, R.V. and M.M. Gruebel (Editors). 1991. *Background Information Presented to the Expert Panel on Inadvertent Human Intrusion into the Waste Isolation Pilot Plant.* SAND91-0928. Albuquerque, NM: Sandia National Laboratories.

Hora, S.C., D. Von Winterfeldt, and K.M. Trauth. 1991. *Expert Judgment on Inadvertent Human Intrusion into the Waste Isolation Pilot Plant.* SAND90-3063. Albuquerque, NM: Sandia National Laboratories.

Human Interference Task Force. 1984. *Reducing the Likelihood of Future Human Activities That Could Affect Geologic High-Level Waste Repositories.* BMI/ONWI-537. Columbus, OH: Battelle Memorial Institute.

International Atomic Energy Agency. 1996. *Maintenance of Records for Deep Geological Repositories.* 1996-05-31.

Kaplan, M.F. 1982. *Archaeological Data and Basis for Repository Marker Design.* ONWI-354. Reading, MA: The Analytic Sciences Corporation.

Public Law 102-579, *Land Withdrawal Act of 1992.*

Sebeok, T.A. 1984. *Communication Measures to Bridge Ten Millennia.* BMI/ONWI-532. Columbus, OH: Battelle Memorial Institute.

Silva, M.K. 1994. *Implications of the Presence of Petroleum Resources on the Integrity of the WIPP.* EEG-55. Albuquerque, NM: Environmental Evaluation Group.

Silva, M.K., and J.K. Channell. 1992. *Implications of Oil and Gas Leases at the WIPP on Compliance with EPA TRU Waste Disposal Standards.* EEG-50. Albuquerque, NM: Environmental Evaluation Group.

Swift, Peter. 1996. Peer Review Panel Meeting. Albuquerque, NM: Sandia National Laboratories. June 7, 1996.

Tannenbaum, P.H. 1984. *Communication Across 300 Generations: Deterring Human Interference With Waste Deposit Sites.* BMI/ONWI-535. Columbus, OH: Battelle Memorial Institute.

Trauth, K.M. 1996. Peer Review Panel Meeting. Albuquerque, NM: Sandia National Laboratories. June 24, 1996.

Trauth, K.M., R.V. Guzowski, C.G. Pflum, and R.J. Rodriguez. 1996. *Effectiveness of Passive Institutional Controls in Reducing Inadvertent Human Intrusion into the Waste Isolation Pilot Plant for Use in Performance Assessments.* WIPP/CAO-06-3168. U.S. Department of Energy.

Trauth, K.M., S.C. Hora, and R.V. Guzowski. 1992. *Expert Judgment on Markers to Deter Inadvertent Human Intrusion into the Waste Isolation Pilot Plant.* SAND92-1382. Albuquerque, NM: Sandia National Laboratories.

DOE. 1996a. *Passive Institutional Controls Conceptual Design Report.* Rev. 0. U.S. Department of Energy.

DOE. 1996b. *Compliance Certification Application: Appendix DEL.* U.S. Department of Energy. Draft appendix of application to be submitted to the U.S. Environmental Protection Agency, October 1996.

EPA. 1985. "40 CFR Part 191, Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes; Final Rule." U.S. Environmental Protection Agency. *Federal Register,* Vol. 50, No. 182, pp. 38066-38089.

EPA. 1993. "40 CFR Part 191, Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes; Final Rule." U.S. Environmental Protection Agency. *Federal Register,* Vol. 58, No. 242, pp. 66398-66416.

EPA. 1996a. *Compliance Application Guidance for 40 CFR Part 194.* EPA 402-R-95-014. Washington, D.C.: U.S. Environmental Protection Agency, Office of Radiation and Indoor Air.

EPA. 1996b. "40 CFR Part 194, Criteria for the Certification and Re-Certification of the Waste Isolation Pilot Plant's Compliance With the 40 CFR Part 191 Disposal Regulations, Final Rule." U.S. Environmental Protection Agency. *Federal Register,* Vol. 61, No. 28, pp. 5224-5245.

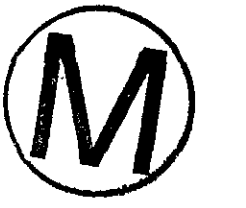
EPA. 1996c. *Criteria for the Certification and Re-Certification of the Waste Isolation Pilot Plant's Compliance with the 40 CFR Part 191 Disposal Regulations. Background Information Document. Chapter 12.* EPA 402-R-96-002. Washington, D.C.: U.S. Environmental Protection Agency, Office of Radiation and Indoor Air.

EPA. 1995a. *Environmental Protection Agency Technical Workshop on WIPP Compliance Issues: February 14-16, 1995.* Washington, D.C.: U.S. Environmental Protection Agency (Neil R. Gross).

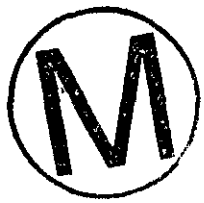
EPA. 1995b. *Minutes of September 6-7, 1995, Meeting of WIPP Review Committee National Advisory Council for Environmental Policy and Technology (NACEPT).* Washington, D.C.: U.S. Environmental Protection Agency, Office of Air and Radiation.

NRC. 1988. *Peer Review for High-Level Nuclear Waste Repositories.* NUREG-1297. Washington, D.C.: U.S. Nuclear Regulatory Commission.

Weitzberg, A. 1982. *Building on Existing Institutions to Perpetuate Knowledge of Waste Repositories.* ONWI-379. Rockville, MD: NUS Corporation.



Determination of Peer Review Member Independence Form



_____ Currently employed by DOE or DOE Contractor? Yes (No)

_____ Employed by DOE or DOE Contractor previously? (Yes) No

If yes, give dates, location, company, position type work performed.

7/92 - 1/96 Albuquerque, NM Sandia National Laboratories

position: member of technical staff manager

type of work: policy analysis, strategic planning, management

See attached letter for further information

_____ Do you or have you had any direct involvement or financial interest in the work under review? Yes (No)

If yes, describe involvement.

I hereby certify that the above information is correct to the best of my knowledge. I was not involved as a participant, supervisor, technical reviewer, or advisor in the work being reviewed. and to the extent practical, I have sufficient freedom from funding considerations to ensure the work is impartially reviewed.

Signature: [signature]

Date: 5/22/96

Peer Review Manager Approval: [signature] John A. Thies

5/28/96
Date

Determination of Peer Review Member Independence Form

_____ Currently employed by DOE or DOE Contractor? (Yes)/No

_____ Employed by DOE or DOE Contractor previously? Yes/No

If yes, give dates, location, company, position type work performed.

12-89 to present — I am employed by Argonne National Laboratory and work in the Washington DC office. I am a policy analyst and work on environmental, statutory and regulatory issues affecting federal facilities (DOE specifically).

_____ Do you or have you had any direct involvement or financial interest in the work under review? Yes/(No)

If yes, describe involvement.

I hereby certify that the above information is correct to the best of my knowledge. I was not involved as a participant, supervisor, technical reviewer, or advisor in the work being reviewed, and to the extent practical, I have sufficient freedom from funding considerations to ensure the work is impartially reviewed.

Signature: Elizabeth K. Hoekzema

Date: 22 May '96

M

Peer Review Manager Approval: John A. Thies 5/28/96

Date

Determination of Peer Review Member Independence Form

YES — Currently employed by DOE or DOE Contractor? Yes/No
Employed by DOE or DOE Contractor previously? (Yes)/No

If yes, give dates, location, company, position type work performed.

See attached descriptions
Descriptions relate to projects carried out by Golder Associates Inc.
Personal Involvement:
#25 : translation of two french technical articles concerning grouts
#39 : spatio-temporal analysis of Vulcanism at Yucca Mt.
development of interface between fehmn and fracman codes
#40 : data analysis support for fracture flow models at Yucca Mt.
NO #42: Reservoir engineering/geology at Yates Field for tertiary recovery process.

Do you or have you had any direct involvement or financial interest in the work under review? Yes/No

If yes, describe involvement.

I hereby certify that the above information is correct to the best of my knowledge. I was not involved as a participant, supervisor, technical reviewer, or advisor in the work being reviewed, and to the extent practical, I have sufficient freedom from funding considerations to ensure the work is impartially reviewed.

Signature: Paul R. LaPointe

Date: 5/6/96

M M

Peer Review Manager Approval: John A. Thies — 5/28/96 Date

	Prime Contract No.	Prime Contractor	Subcontract Number	Subcontractor	Subtier Contract No.	Contract Type	Period of Performance	Contract Value	Contract Summary
1	DE-AC06-87RL10930	Westinghouse Hanford Company POC: Mr. David Wilson PO Box 1970 Richland, WA 99352 Phone: (509) 376-0372	MLW-SVV-073750	Science Applications International Corp. POC: Mr. PK Brockman 3250 Port of Benton Blvd Richland, WA 99352 Phone: (509) 372-7700	16-9100011-61	Task Order CPFF	Jun 91 - Apr 95	$11.447 M	Geotechnical support services
2	W-7405-Eng-36	University of California POC: Mr. George Daly Los Alamos National Laboratory PO Box 990 Los Alamos, NM 87545 Phone: (505) 665-7891	9-X69-C4600-1	Not applicable	Not applicable	CPFF	Jun 89 - Sep 93	$145 K	Technical support for site characterization of Yucca Mountain, NV
3	W-7405-Eng-36	University of California POC: Ms. Allison Bailey Los Alamos National Laboratory PO Box 990 Los Alamos, NM 87545 Phone: (505) 665-3900	9-XS2-F2078-1	ERM Program Management Company POC: Mr. Pat Heenan 855 Springdale Drive Exton, PA 19341 Phone: (610) 524-3899	LANL-PMC-Sub1	Task Order CPFF	Jul 92 - Jul 97	$5.644 M	Environmental support services to LANL Environmental Restoration Program
4	DE-AC07-76IDO1570	EG&G Idaho, Inc. POC: Mr. Robert Crowton PO Box 1625 Idaho Falls, Idaho 83415 Phone: (208) 526-7746	C92-120273	Not applicable	Not applicable	CPFF	Feb 92 - Sep 92	$174K	Technical support services in support of the DOE Subsurface Science Subprogram
5	DE-AC07-76IDO1570	EG&G Idaho, Inc. POC: Ms. Tonya Pearson PO Box 1625 Idaho Falls, Idaho 83415 Phone: (208) 526-1544	C91-103366	Not applicable	Not applicable	CPFF	Apr 91 - Sep 92	$185 K	Support to NPR
6	DE-AC07-76IDO1570	EG&G Idaho, Inc. POC: Ms. Tonya Pearson PO Box 1625 Idaho Falls, Idaho 83415 Phone: (208) 526-1544	C91-103242	Not applicable	Not applicable	CPFF	Apr 91 - Sep 92	$893 K	Synthesize existing data and perform studies necessary to establish the seismic design for the NPR site and to determine risk from other geologic hazards.
7	DE-AC07-76IDO1570	EG&G Idaho, Inc. POC: Ms. Linda Baum PO Box 1625 Idaho Falls, Idaho 83415 Phone: (208) unavailable	C88-1131159	Not applicable	Not applicable	Task Order CPFF	Dec 88 - Sep 91	$2.621 M	Technical support servics in the area of radioactive waste management
8	DE-AC07-76IDO1570	EG&G Idaho, Inc. POC: Mr. Scott Hancock PO Box 1625 Idaho Falls, Idaho 83415 Phone: (208) 526-3499	C90-132736	Not applicable	Not applicable	Task Order CPFF	May 90 - Jul 93	$4.403 M	Support services for radioactive and hazardous waste management
9	DE-AC06-87RL10930	Westinghouse Hanford Company Ms. Lynn Aman PO Box 1970 Richland, WA 99352 Phone: (509) 376-4811	MRY-SVV-301407	Not applicable	Not applicable	FFP, T&M	Sep 93 - Sep 94	364 K	Engineering suport for WRAP and solid waste projects. Provide engineering services to design a trench
10	DE-AC06-87RL10930	Westinghouse Hanford Company Ms. Sylvia Horais PO Box 1970 Richland, WA 99352 Phone: (509) 376-6777	MSH-SVV-315905	Not applicable	Not applicable	Fixed Unit Rates	Aug 94 - Sep 95	$200 K	Validate chemical and radiochemical data packages and provide summary reports of validated data from site characterization activities
11	DE-AC06-87RL10930	Westinghouse Hanford Company Mr Robert Young PO Box 1970	MJK-SVV-301401	Not applicable	Not applicable	Labor Hours	Jan 93 - Dec 99	$36 K	Design, engineering and inspection services in support of W-025 Project.

5/6/98

Prime Contract No.	Prime Contractor	Subcontract Number	Subcontractor	Subtier Contract No.	Contract Type	Period of Performance	Contract Value	Contract Summary
	Richland, WA 99352 Phone: (509) 376-8766							
DE-AC06-87RL10930 12	Westinghouse Hanford Company Mr. Robert Young PO Box 1970 Richland, WA 99352 Phone: (509) 376-8766	MRV-SVV-666693	Not applicable	Not applicable	Task Order CPFF	Oct 89 - Sep 93	$1.875 M	Geotechnical support services
DE-AC06-76RLO 1830 13	Battelle Pacific Northwest Laboratory Ms. Robin Rosengrant PO Box 999 Richland, WA 99352 Phone: (509) 375-4587	283407-A-B2	Not applicable	Not applicable	Labor Hours	Jun 94 - May 95	$20 K	In-situ vitrification geotechnical support of Hanford field demonstration
DE-AC06-76RLO 1830 14	Battelle Pacific Northwest Laboratory Ms. Robin Rosengrant PO Box 999 Richland, WA 99352 Phone: (509) 375-4587	283446-A-B2	Not applicable	Not applicable	Labor Hours	Sep 94 - Nov 94	$13 K	Analysis of stability of overburden for Oak Ridge National Laboratory in-situ vitrification design
DE-AC06-87RL10930 15	Westinghouse Hanford Company Ms. Tracey A. Burch PO Box 1970 Richland,. WA 99352 Phone: (509) 376-7206	TTB-SLC-352143	Not applicable	Not applicable	Task Order CPFF	Jan 94 - Sep 97	$8.649 M	Support Hanford environmental compliance program including waste site permiting, vadose dose and groundwater characterizations, and geophysical investigations
DE-AC06-76RLO 1830 16	Battelle Pacific Northwest Laboratory POC: Ms. Nancy K. Powell PO Box 999 Richland, WA 99352 Phone: (509) 375-3771	110720-A-P1	Not applicable	Not applicable	CPFF	Sep 90 - Dec 90	$48 K	Support PASS Program and OCRWM through application of FracMan to describe fracture systems within Yucca Mt.
DE-AC06-76RLO 1830 17	Battelle Pacific Northwest Laboratory POC: Ms. Nancy K. Powell PO Box 999 Richland, WA 99352 Phone: (509) 375-3771	110707-A-P1	Not applicable	Not applicable	Labor Hour	Jun 90 - Feb 91	$89 K	Coordinate US participation in INTRAVAL Cooperative Study for DOE HQ
DE-AC06-76RLO 1830 18	Battelle Pacific Northwest Laboratory POC: Ms. Kala Suhadolnik PO Box 999 Richland, WA 99352 Phone: (509) 376-8818	151578-B-C5	Not applicable	Not applicable	Labor Hours	Oct 93 - Jul 94	$41 K	Complete validation studies and perform sensitivity and uncertainty analyses of the Hanford Environmental Dose Reconstruction dose calculation codes
DE-AC06-76RLO 1830 19	Battelle Pacific Northwest Laboratory POC: Ms. Nancy K. Powell PO Box 999 Richland, WA 99352 Phone: (509) 375-3771	76940-A-B1	Not applicable	Not applicable	Task Order Labor Hours	Mar 89 - Dec 91	$50 K	Technical support to include: remedial investigation planning, remedial investigation execution, site assessments, feasibility studies, and independent reviews and regulatory analyses.
DE-AC06-76RLO 1830 20	Battelle Pacific Northwest Laboratory POC: Mr. Doug Gilbertson PO Box 999 Richland, WA 99352 Phone: (509) 375-5907	134571-A-P1	Not applicable	Not applicable	Labor Hours	Mar 91 - Sep 92	$269 K	Support PASS Program and OCRWM through application of rock mechanics in performance assessment of high-level wastes in mined geologic repositories.

Prime Contract No.	Prime Contractor	Subcontract Number	Subcontractor	Subtier Contract No.	Contract Type	Period of Performance	Contract Value	Contract Summary
DE-AC06-76RLO 1830 21	Battelle Pacific Northwest Laboratory POC: Ms. Julie Wilson PO Box 999 Richland, WA 99352 Phone: (509) 375-6785	228298-A-B3	Not applicable	Not applicable	Labor Hours	Sep-94	$120 K	Conduct field sampling projects at Cerro Negro, NM, and Parachute, CO, in support of DOE's Deep Microbiology Subprogram.
DE-AC04-76DP00789 22	Sandia National Laboratories Mr. Bill Peters PO Box 5800 Albuquerque, NM Phone: (606) 844-4438	AA-1994	Not applicable	Not applicable	Labor Hours	Jan 92 - Dec 92	$45K	Technical review of plans and procedures for hydraulic fracturing and hydrologic tests. Review and provide recommendations for specific analytical approaches.
DE-AC04-94AL85000 23	Sandia National Laboratories Mr. Craig Amundson PO Box 5800 Albuquerque, NM Phone: (505) 844-0814	AL-7026	Not applicable	Not applicable	Time & Materials	Dec 94 -Oct 95	$200 K	Conduct baselining and quality assurance of the Repository Integration Program in the System Prioritization Methodology and modify RIP conceptual model as required.
DE-AC04-94AL85000 24	Sandia National Laboratories Mr. Bill Peters PO Box 5800 Albuquerque, NM Phone: (505) 844-4438	AM-8859	Not applicable	Not applicable	Task Order CPFF	May 95 - Sep 96	$422 K	Technical support services to include: interpretation of post-test characterization data enhance/extend EnviroTRADE databases
DE-AC04-76DP00789 25	Sandia National Laboratories Mr. Bill Peters PO Box 5800 Albuquerque, NM Phone: (505) 844-4438	87-3497	Not applicable	Not applicable	Time & Materials	Dec 91 - May 95	$1,993 M	Support DOE/EM's International Technology Exchange Program by developing methodology for decision making on ER of contaminated sites and testing of grout barriers
W-31-109-Eng-38 26	Argonne National Laboratory Mr. John Wray 9700 Cass Avenue South Argonne, IL 60439 Phone: (708) 252-548	92722402	Not applicable	Not applicable	Labor Hours	Oct 89 - Apr 91	$172 K	Support the Stripa Fracture Flow Task Force and the OECD/NEA Site Evaluation and Design of Experiments Working Group through test interpretation and predictive modelling
W-31-109-Eng-38 27	Argonne National Laboratory Mr. John Wray 9700 Cass Avenue South Argonne, IL 60439 Phone: (708) 252-548	9029-W	Not applicable	Not applicable	FFP	Jan 91 - Jul 91	$591 K	Site characterization, monitoring, analysis and test plan for the EBR II leach pit
W-31-109-Eng-38 28	Argonne National Laboratory Mr. Michael Janik 9700 Cass Avenue South Argonne, IL 60439 Phone: (708) 252-548	942682403	Not applicable	Not applicable	Labor Hours	Oct 94 - Dec 96	$110 K	Review of service experience related to steam generator tube degredation in commercial reactors. Coordinate and facilitate information exchange with Electric Power Research Institute.
W-31-109-Eng-38 29	Argonne National Laboratory Mr. Michael Janik 9700 Cass Avenue South Argonne, IL 60439 Phone: (708) 252-5481	2352401	Not applicable	Not applicable	Labor Hours	Nov 90 - Sep 93	$894 K	Alternative licensing strategies investigation and strategic plan for site suitability determination
W-31-109-Eng-38 30	Argonne National Laboratory Mr. Michael Janik 9700 Cass Avenue South Argonne, IL 60439 Phone: (708) 252-5481	942C82402	Not applicable	Not applicable	Labor Hours	Jun 94 - Feb 95	$28 K	Conduct high resolution subbottom profiling high resolution seismic reflection profiling, medium resolution seismic reflection profiling, and seismic refraction sounding in the waters near Aberdeen Proving Ground

Prime Contract No.	Prime Contractor	Subcontract Number	Subcontractor	Subtier Contract No.	Contract Type	Period of Performance	Contract Value	Contract Summary
W-31-109-Eng-38 31	Argonne National Laboratory Mr. Steve Gihring 9700 Cass Avenue South Argonne, IL 60439 Phone: (208) 533-7708	31-109-38-8322-W	Not applicable	Not applicable	Fixed Unit Rates	Jan 84 - Apr 95	$353 K	Investigation and characterization of liquid effluent discharges
DE-AC06-89RL11165 32	DOE - Richland Operations Office Ms. Sally Sierecki PO Box 550 Richland, WA 99352 Phone: (509) 376-2955		Not applicable	Not applicable	FFP, CPFF	Oct 89 - Dec 94		Perform A-E services for definitive design, engineering during construction, engineering field services, and Part B Permit engineering support for radioactive mixed waste land disposal facility - Non Drag On
DE-FG06-92ER61507 33	DOE - Richland Operations Office Ms. Marjie Parker PO Box 550 Richland, WA 99352 Phone: (509) 376-6227		Not applicable	Not applicable	CR grant	Oct 93 - Sep 96	$1.6 M	Subsurface science geologic data interpretation and technical support
DE-AC04-93AL93904 34	Advanced Sciences, Inc. POC: Ms. Frances Lopez PO Box 1270 Carlsbad, NM 88221 Phone: (505) 885-0085	9121-803-018	Not applicable	Not applicable	Labor Hours	Nov 95 - Sep 96	$155 K	Performance assessment modelling of Waste Isolation Pilot Program. Technical Reviews of WIPP site documents.
DE-AC04-93AL93904 35	Advanced Sciences, Inc. POC: Mr. Mike Holston 6738 Academy Road, NE Albuquerque, NM 87109 Phone: (505) 828-0859	9622-BR-15-94	Not applicable	Not applicable	Labor Hours	Feb 94 - Sep 95	$616 K	Performance assessment modelling of Waste Isolation Pilot Program. Technical Reviews of WIPP site documents.
W-7405-Eng-82 36	Ames Laboratory POC: Mr. Jack Cummings 133 Spedding Hall Iowa State University Ames, Iowa 50011-3020 Phone: (515) 294-1790	PO # A4-2804	Not applicable	Not applicable	Fixed Unit Rates	Mar-94	$10 K	Expedited site characterization demonstration
DEAC07-88-ID12735 37	MSE, Inc. POC: Mr Charles Reis PO Box 4078 Butte, MT 59702 Phone: (406) 723-8213	95-C289-CR	Not applicable	Not applicable	CPFF	Jul 95 - Sep 95	$61 K	Post-injection characterization of foreign grout study at the Richland Municipal Landfill
DE-AC34-90-RF62349 38	EG&G Rocky Flats, Inc. Rocky Flats Plant POC: Mr. D. Patrick Timbes PO Box 464 Golden, CO 80402 Phone: (303) 966-8592	MTS 225469DB	Not applicable	Not applicable	Labor Hours	Aug 92 - Sep 95	$5.392 M	Environmental and waste management sampling support and associated technical analysis
DE-AC01-91RW0 0134 39	TRW Environmental Safety Systems POC: Mr. Jeff Shuse 2650 Park Tower Drive, Suite 800 Fairfax, VA 22033 Phone: (703) 204-8500	DX1426KP2L DX1466KP3S	Not applicable	Not applicable	CPFF	Oct 93 - Jul 95	$$661 K	Use of RIP software in performance assessment modelling of Yucca Mt in support of DOE INTRAVAL program
DE-AC01-92EW30030 40	BDM Federal, Inc. POC: Mr. Steven Fuck 1501 BDM Way McLean, VA 22030 Phone: (703) 848-5745	08S20016 0893005504 0893008804	Not applicable	Not applicable	CPFF	Oct 93 - Sep 95	$885 K	Technical support for WIPP including modelling and demonstration of disposal of transuranic waste
'34-CR-95-SA-1023 41	Golder Associates 4104 148th Ave. NE Redmond, WA 98052 (206) 883-0777				FFP	Apr 95 - Apr 96	$32K	

5/3/95

DE-AC22-94PC91005	BDM-Oklahoma	G4S51728	FFP	Performance	Amount
#42	220 NW Virginia Ave Bartlesville, OK 74005 POC: Dr. M. Madden (918) 337-4261			Mar 96 - Nov. 98	$743K