NUCLEAR REGULATORY COMMISSION

ORIGINAL

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of:	:	
	:	
UNITED STATES DEPARTMENT OF ENERGY	:	
PROJECT MANAGEMENT CORPORATION	:	
	:	DOCKET NO. 50-537
TENNESSEE VALLEY AUTHORITY	:	
(Clinch River Breeder Reactor Plant)	:	

DATE: August 27, 1982 PAGES: 2804 - 3217

AT: Oak Ridge, Tennessee

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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UNITED STATES DEPARTMENT OF ENERGY	x	
PROJECT MANAGEMENT CORPORATION	x	Docket No. 50-537
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TENNESSEE VALLEY AUTHORITY	x	
(Clinch River Breeder Reactor Plant)	x	

Hemlock Room

Executive Seminar Center Building

301 Broadway

Oak Ridge, Tennessee

Friday, August 27, 1982

The hearing in the above-entitled matter was convened, pursuant to adjournment, at 8:30 a.m.

BEFORE:

MARSHALL E. MILLER, Chairman

GUSTAVE A. LINENBERGER, JR., Member

CADET HAND, Member

PRESENT:

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-and-

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Representing the U. S. Nuclear Regulatory Commission:

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U. S. Nuclear Regulatory Commission
Washington, D. C. 20006

C O N T E N T S

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E X H I B I T S

NUMBER	IDENTIFIED	RECEIVED
Intervenors' Exhibit 1	- - -	3145
Intervenors' Exhibit 2	- - -	3144
Intervenors' Exhibit 3	- - -	2809
Intervenors' Exhibit 4	- - -	3143
Intervenors' Exhibit 8	2875	3143
Intervenors' Exhibit 9	2879	3143
Intervenors' Exhibit 10	2892	- - -
Intervenors' Exhibit 10A	3190	3190
Applicants' Exhibit 33	2985	3148
Staff's Exhibit 6	3192	3192

1-1
b

P R O C E E D I N G S

8:30 a.m.

JUDGE MILLER: All right. Are we ready to start our next phase of the hearing, please?

MS. FINAMORE: Yes.

The first matter, which is a holdover from yesterday, is that I would like to offer Intervenors' Exhibit 3 into evidence.

JUDGE MILLER: Any objections?

(No response.)

JUDGE MILLER: It may be received.

That's the testimony, isn't it?

MS. FINAMORE: Yes.

JUDGE MILLER: That will be received.

(The document heretofore marked for identification as Intervenors' Exhibit No. 3 was received in evidence and is hereby incorporated into the record.)

Int. Ex 3

2810

BEFORE THE
UNITED STATES NUCLEAR REGULATORY COMMISSION
ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
UNITED STATES DEPARTMENT OF ENERGY PROJECT MANAGEMENT CORPORATION TENNESSEE VALLEY AUTHORITY	)	Docket No. 50-537
(Clinch River Breeder Reactor Plant)	)	

TESTIMONY OF DR. THOMAS B. COCHRAN

Part I

My name is Thomas Brackenridge Cochran. I reside at 4836 North 30th Street, Arlington, Virginia 22207. I am presently a Senior Staff Scientist at Natural Resources Defense Council, Inc. I am a member of the Department of Energy's Energy Research and Advisory Board; the Three Mile Island (TMI) Public Health Fund Advisory Board; the Nuclear Regulatory Commission's TMI Advisory Board; and the American Nuclear Society.

I have a B.S. degree in electrical engineering and M.S. and Ph.D. degrees in physics, all from Vanderbilt University. I have held the positions of Assistant Professor of Physics, U.S. Naval Postgraduate School, and Senior Research Associate, Resources for the Future.

I have been a consultant to numerous government agencies and testified before Congress on numerous occasions on matters related to nuclear energy generally and liquid metal fast breeder reactors (LMFBRs) in particular. I was a member of DOE's

Nonproliferation Advisory Panel and ERDA's LMFBR Review Steering Committee. I am the author of The Liquid Metal Fast Breeder Reactor, An Environmental and Economic Critique, (Johns Hopkins Univ. Press, 1974).

With regard to matters of LMFBR safety, I was also a member of the NRC's Advisory Group on Reactor Safety Goals and NRC's Advisory Group on Operator Training. I have had extensive hands-on experience with systems modeling and computer programming, both in relation to my Ph.D. dissertation in high energy physics and while serving as a Modeling and Simulation Group Supervisor at Litton Scientific Support Laboratory at Fort Ord, California. I was one of two U.S. citizens invited to testify on safety aspects of the SNR-300, the Federal Republic of Germany's demonstration breeder, before the Enquete-Kommission "Zukunftige Kernenergie-Politik," Deutscher Bundestag, FRG (June 3, 1982).

With regard to radiation protection, my M.S. thesis was in Radiation Chemistry. I was an AEC Health Physics Fellow at Vanderbilt University between 1962 and 1964, during which period I had 3 months of on-the-job training at Oak Ridge National Laboratory. I was the campus Radiation Safety Officer while pursuing my Ph.D. degree at Vanderbilt University. While at NRDC I co-authored with Dr. Arthur Tamplin two radiation standards petitions to the NRC, "Petition to Amend 10 CFR 20.101, Exposure of Individuals to Radiation in Restricted Areas," September 1975 (PRM-20-6), and "Petition to Amend Radiation Protection Standards as They Apply to Hot Particles," February 1974 (PRM-20-5). I have been a member of the Health Physics Society for the past 18

or so years. For further information regarding my background and qualifications, please consult the attached copy of my resume.

Introduction

Intervenors' Contention 1 a) is as follows:

> 1. The envelope of DBAs should include the CDA.
>
> a) Neither Applicants nor Staff have demonstrated through reliable data that the probability of anticipated transients without scram or other CDA initiators is sufficiently low to enable CDAs to be excluded from the envelope of DBAs.

Intervenors' Contention 3 b) and d) are as follows:

> 3. Neither Applicants nor Staff have given sufficient attention to CRBR accidents other than the DBAs for the following reasons:
>
> b) Neither Applicants' nor Staff's analyses of potential accident intiators, sequences, and events are sufficiently comprehensive to assure that analysis of the DBAs will envelop the entire spectrum of credible accident initiators, sequences, and events.
>
> d) Neither Applicants nor Staff have adequately identified and analyzed the ways in which human error can initiate, exacerbate, or interfere with the mitigation of CRBR accidents.

Contentions 1 b) and 3 a), which specifically claimed that Applicants' so-called reliability program and probability risk assessments do not provide a basis for excluding the core disruptive accident (CDA) from the Clinch River Breeder Reactor (CRBR) design basis were deferred by order of the Board until the Construction Permit hearings. Site suitability aspects of Contention 3 c) are addressed along with Contention 2 issues in

the second part of my testimony. This first part of my testimony on Contentions 1 a) and 3 b) and d) also relates directly to Contention 2.

The proposed CRBR is a single-unit electric power plant with a sodium-cooled loop-type breeder reactor utilizing a fuel of mixed uranium-plutonium oxides. With the initial reactor core, the power level is designed to be 975 MW_t, and the net output is designed to be 350 MW_e.

A core disruptive accident, or CDA, has been defined by the Applicants as an LMFBR accident "in which there are overheating and subsequent fuel melting and relocation." ("CRBRP Safety Study," An Assessment of Accident Risks in the CRBRP, CRBRP-1, March, 1977 at 3-17.) A CDA was described further by Applicant as follows:

> CDA means a loss of coolable configuration of the reactor core. It covers a spectrum of highly improbable accidents ranging from those involving partial fuel melting to those in which a bubble of fuel vapor, assumed to form in the core during the accident as a result of a rapid temperature transient, expands rapidly.

Id. at E-23. With the exception of the assertion contained in the quoted material with regard to the probability of the event, the above accurately describes a CDA and is consistent with NRDC's use of the term throughout our contentions.

The term "design basis" is used in the context of nuclear licensing to denote the range of postulated accidents for which it is required to provide protection in the form of engineered safety features systems. In other words, a nuclear plant must contain highly reliable, redundant, diverse systems meeting the

requirements of 10 CFR Part 50 and Appendices to ensure that all design basis accidents will be mitigated without significant health and safety consequences. A reactor design is acceptable only if the safety systems of the plant can mitigate the range of design basis accidents. Indeed, NRC so defines safety systems:

> Basic safety systems are those that directly perform a protective function. Examples are the reactor trip system, the emergency core cooling system, the containment isolation system, and the containment spray system. The reactor trip system provides reactor protection by fast insertion of negative reactivity (control rods) when plant conditions approach design safety limits. All other systems listed are engineered safety features (ESF) systems, their function is to mitigate the consequences of postulated design basis accidents.

NUREG-75/087, Standard Review Plan, §7.1, Part III.

For the CRBR, the design basis as currently proposed by the Applicants does not include a CDA. That is, accidents which could result in core melting or substantial core damage are excluded. The proposed "allowable limit" for a so-called "extremely unlikely fault," the Applicants' terminology for the most severe design basis accident, is stated to be "maintaining coolable geometry." (PSAR at 15.1-51) The Applicants' proposed criteria for ensuring that the core will remain coolable are described as follows:

> This limit is considered to be met when the cladding temperature is held below the melting point. If there is no cladding melting then no gross cladding relocation or gross channel blockage can occur. Therefore, preventing cladding temperatures from exceeding the melting temperature will ensure maintaining a coolable core geometry.
>
> Before the cladding melting temperature can be reached, it is necessary to first

> experience bulk sodium boiling and then dryout of the cladding. The prevention of sodium boiling is considered as a necessary and sufficient criterion for ensuring a core coolable geometry.

(Id., emphasis added).

Thus, according to the Applicants' proposed CRBR acceptance criteria, in order to ensure coolable geometry, there must be no sodium boiling and no clad or fuel melting. It is therefore reasonable to define a CDA as an accident involving the onset of sodium boiling or clad or fuel melting.

Since the design basis for nuclear plants excludes some accidents that are possible and that could have very large consequences if they occurred, it is either implicit or explicit that this exclusion is based on the judgment that such accidents are so improbable as to be incredible. This process of dividing possible accidents into classes (Class 1-8 are "credible" accidents of increasing severity; Class 9 are alleged to be "incredible" accidents of high consequences and, it is asserted, the lowest probability) is described at page 7-2 of the 1977 FES:

> In establishing the boundary between accident sequences that are to be within the design basis envelope (classes 1-8), and hence for which engineered safety features are provided, and accidents that may reasonably be assigned to the residuum for which no further protective features are normally necessary (class 9), the NRC staff in the past has used the safety objective that the risk to the public from all reactor accidents should be very small compared to most other risks of life, such as disease or natural catastrophe. The staff believes this safety objective is met by requiring a design basis accident envelope that extends to very unlikely postulated accidents, with the objective that there be no greater than one chance in one million per year for potential

consequences greater than 10 CFR 100 guidelines for an individual plant.

(Emphasis added.) Thus, for the CRBR, the Staff has explicitly articulated the goal that the probability of accidents with sequences beyond 10 CFR 100 guidelines shall be no greater than 10^{-6} per year of operation.

This goal is consistent with prior NRC practice. Although the goal has not always been stated in numerical terms, there are precedents for this. For example, Section 2.2.3 of the NRC's Standard Review Plan, dealing with the evaluation of potential accidents in the vicinity of a proposed nuclear plant, provides as follows:

> II. ACCEPTANCE CRITERIA
>
> The identification of design basis events resulting from the presence of hazardous materials or activities in the vicinity of the plant is acceptable if the design basis events include each postulated type of accident for which a realistic estimate of the probability of occurrence of potential exposures in excess of the 10 CFR Part 100 guidelines exceeds the NRC staff objective of approximately 10^{-7} per year.

The section provides further that, in lieu of the "realistic" calculation described above, an applicant may demonstrate compliance if a "conservative" calculation shows that the probability of occurrence of potential exposures in excess of the Part 100 guidelines is approximately 10^{-6} per year.

NRC has been licensing light-water nuclear power reactors ("LWR's") for some 25 years. Until the TMI accident, the opinion of the industry and of the AEC and NRC was that substantial fuel melting was an "incredible" accident for an LWR. Thus, the

design basis for LWR's did not include fuel melting to any significant degree.[1]

However, the TMI accident involved core damage far in excess of that postulated within the design basis. It is generally accepted that between 30% and 50% of the TMI-2 core was damaged. NRC's Special Inquiry Group concluded:

> In a more technically accurate sense, the TMI-2 accident progression was such that a substantial fraction of the fuel was near the temperature required for formation of fuel-clad eutectic material, so that a loss of coolable fuel geometry was very possible.[2]

In the wake of the TMI-2 accident, NRC has changed many of its requirements for licensing LWR's. While the agency has not yet determined how to treat a "degraded core" accident in all respects, the regulations do now include some requirements for which substantial core damage is essentially a "design basis" event. For example, 10 CFR 50.44(c)(3)(iii) requires the installation of high point vents for the reactor coolant system, the reactor vessel head and other systems required for adequate core cooling if the accumulation of noncondensible gases would cause the loss of function of their instrumentation controls and power sources. The high point vents, like all other systems

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[1] The Commission's regulations on emergency core cooling systems contemplated that no more than about 1% of the fuel cladding will reach temperatures at which it would react with coolant. See 10 CFR 50.46(b)(3); Duke Power Co. (William B. McGuire Nuclear Station, Units 1 and 2), separate views of Commissioners Gilinsky and Bradford, 14 NRC 5 (July, 1981).

[2] Three Mile Island, Report to The Commissioners and to the Public, NRC Special Inquiry Group, vol. 2, Part 2, January 1980, p. 537.

important to safety, must meet the requirements of 10 CFR Part 50, Appendices A and B which include redundancy, diversity, environmental qualification, testability, etc.

These vents would only be necessary in the event of an accident involving substantial core damage, to remove the noncombustible gas resulting from the reaction of overheated fuel cladding and coolant. Thus, substantial core damage in an LWR is a "design basis" event for at least some purposes. While I do not believe that this is sufficient protection against core damage or core melt accidents, the fact is that it is not entirely accurate to maintain that such accidents are still viewed as "incredible" for purposes of licensing LWR's.

Moreover, there are, in my view, strong reasons for treating CDA's as design basis events for the CRBR and, as I will discuss below, ample precedent in the history of fast reactors for doing so. The CRBR is different from an LWR in at least four respects which compel providing full protection against a CDA; that is, providing safety systems meeting the requirements of 10 CFR Part 50 and Appendices, or their equivalent, which would mitigate a CDA without causing releases of radioactivity in excess of the 10 CFR 100 guidelines.

First, an LMFBR can undergo a nuclear explosion. The theoretical upper limit to the explosive potential (i.e., the energetics) of LMFBR's even smaller than CRBR greatly exceeds any practical containment for reactors (assuming they are sited above ground).

Second, a nuclear explosion in an LMFBR provides a potential mechanism for release, in vapor or particulate form, of substantially larger fractions of fuel (plutonium) and fission products to the containment atmosphere, and consequently to the environment, than would be released following a non-energetic core melt accident. This is exacerbated by the fact that LMFBRs generally contain several times the core inventory of the highly toxic isotopes of plutonium than do LWRs.

Third, release of plutonium into the environment following nuclear explosions in LMFBRs potentially represents a far more serious contamination problem than contamination by fission product release (I-131) following LWR core melt accidents, due to the long half-life and extreme toxicity of plutonium. This is evidenced by the still existing quarantine of Runit Island (Enewetak Atoll) and other islands in the Pacific following plutonium contamination for nuclear weapons tests conducted prior to the 1963 Limited Test Ban Treaty.

Fourth, as stated by the NRC Staff before the Advisory Committee on Reactor Safeguards (ACRS):

> the LMFBR technology has a certain lack of solid experience of in-pile test experience, a lack of maturity of the technology which makes preclusion of CDA, or prevention to the likelihood to be next to impossible.

Transcript, Meeting of the ACRS, Nov. 1, 1974, p. 368. That is, in contrast with LWR's, over 150 of which have been licensed for construction, there is virtually no experience with reactors of the general size and type of the CRBR. Moreover, it is not possible to satisfactorily model the behavior of the CRBR core

once cladding melting begins. Even if such modeling could be done with sufficient precision, it has not been. The level of design-specific information required to verify the modeling of CDA behavior for the CRBR is outside the scope of this proceeding.

The view that LMFBRs require a higher standard for protection against CDA compared to LWRs is one shared by others in the technical community. Cave, et al., note for example:

> In principle, one might argue that the same standard of safety (expressed in terms of potential harm to health and damage to property) is appropriate for fast reactors as for thermal reactors. However, in order to define an equivalent safety target for fast reactor, it is necessary to take account of the following factors:
> a) The maximum potential capacity for harm of a fast reactor has been estimated to be about an order of magnitude greater than that for a thermal reactor of the same size ....
> b) The very considerable complexity of analyzing the low probability fault sequences which could lead to core melt down (CMD) and/or pressure-driven disassembly of large fast power reactors, and the consequent uncertainties therein.
> Thus, the fast reactor designer may be in the difficult position of having to demonstrate a higher degree of protection against the more severe fault sequences than is necessary in the case of thermal reactors, and he may be handicapped by greater uncertainty as to the behavior of his reactor in such conditions.

L. Cave, D. Ilberg, and D. Okrent, "Designing for Safety in Fast Reactors in the Presence of Uncertainty,", Proceedings, International Meeting on Fast Reactor Safety and Related Physics, Chicago (Oct. 5-8, 1976) p. 494.

The remainder of my testimony can be outlined as follows:

I. EXPERIENCE WITH DOMESTIC AND FOREIGN FAST REACTORS SUPPORTS INCLUDING CORE DISRUPTIVE ACCIDENTS WITHIN THE CRBR DESIGN BASIS.

A. CDAs Have Been Considered Design Basis Accidents for Domestic and Foreign Fast Reactors.

B. CDAs Have Occurred in the Past.

C. CDAs Were Considered by the NRC to be Credible Events for CRBR Until May 6, 1976.

D. CDAs Cannot Be Excluded from the CRBR Design Basis Without Detailed Design-Specific Analyses.

II. THERE IS NO EMPIRICAL EVIDENCE TO SUPPORT THE PROPOSITION THAT, FOR A REACTOR OF THE GENERAL SIZE AND TYPE AS CRBR, THE PROBABILITY OF A CDA CAN BE MADE SUFFICIENTLY LOW TO JUSTIFY EXCLUDING IT FROM THE DESIGN BASIS FOR CRBR.

A. The Definition of "Sufficiently Low" Can be Derived from the FES and the Denise Letter, Which Establish the Objective That the Probabilty of Exceeding Part 100 Dose Guidelines Be No Greater than 10^{-6} Per Year.

B. At This Stage of the Proceeding, Lacking Design-Specific Analysis of the Progression of a CDA Once Initiated, Compliance with the Objective Requires Showing tha the Probability of Initiating a CDA is Less Than 10^{-6} Per Year.

C. No Reactor Substantially the Same as the CRBR Has Even Been Licensed and No Demonstration Has Even Been Made for a Reactor of the General Size and Type That the Probability of a CDA Was No Greater Than 10^{-6} Per Year.

D. It Has Not Been Shown that the Features of the CRBR Which Are Asserted to prevent CDAs Can Be Made Sufficiently Reliable So That the Probability of Their Failure Is Less than 10^{-6} Per Year.

E. No Showing Has Been Made That Design Criteria Exist for LMFBRs or for CRBR Which, If Met, Would Assure That the Probability of a CDA is Less than 10^{-6} Per Year.

Under these circumstances, the proposition that it is feasible to design CRBR so that the probability of a CDA is incredible is a statement of dogma, not fact.

I. EXPERIENCE WITH DOMESTIC AND FOREIGN FAST REACTORS SUPPORTS INCLUDING CORE DISRUPTIVE ACCIDENTS WITHIN THE CRBR DESIGN BASIS.

The experience to date with liquid metal fast reactors in the U.S. is shown in Table 1.

Table 1

Name	Power Megawatts (Thermal)	Initial Operation
Clementine	0.025	1946
EBR-I	1	1951
LAMPRE	1	1961
EBR-II	62.5	1963
FERMI-I	200	1963
SEFOR	20	1969
FFTF	400	1980

Clementine was a small, mercury-cooled experimental fast reactor located at Los Alamos that was used between 1945 and 1953 to explore the possibility of operating a plutonium fueled fast reactor (USAEC, WASH-1535, Vol. 1, Dec 1974, p. 2.2-2). EBR-I was a small experimental breeder, located at the National Reactor Testing Station in Idaho, used to test the concept of breeding. LAMPRE was a molten plutonium reactor experiment at Los Alamos. (USAEC, WASH-1535, Vol. 1, Dec 1974, p.2.2-4). It reached its design power lever 1 year after criticality and then operated two years until the experiment was terminated in early 1964 (Ibid.).

Thus, Clementine, Experimental Breeder Reactor-I (EBR-I) and LAMPRE were early, relatively small, unlicensed reactors where design basis safety and site suitability considerations were relatively unimportant. Nevertheless, it is noted that the reactor core of EBR-I was inadvertently substantially melted in

an experiment in 1955 involving operator error (USAEC, WASH-1535, Vol. 1, Dec. 1974, p. 2.2-2) The accident was caused in part because automatic safety devices were disconnected.

Experimental Breeder Reactor II (EBR-II) is an unmoderated, heterogeneous, sodium-cooled reactor at Idaho National Engineering Laboratory (INEL, formerly NTES) with power output of 67.5 MW (thermal). It is capable of producing 20 Mw of electricity. It has served as a fast neutron test reactor for the US LMFBR fuels and material program. (USAEC, WASH-1535, Vol 1, Dec 1974, p. 2.2-3). Although it was not licensed and the concepts of "design basis accident" had not evolved at the time EBR-II was constructed, the 1957 "Hazard Summary Report for EBR-II indicates, using "pessimistic" assumptions, that an attempt [was] made to calculate the maximum possible nuclear explosion resulting from a core collapse under gravity" (p. 109), about 1050 lb. TNT equivalent (p. 110), and that the primary containment was designed to contain "without breaching" a "reasonable" upper limit on the explosive energy, about 300 lb TNT.

The Enrico Fermi reactor (FERMI-I) located at Newport Michigan was a 200 mw (thermal) LMFBR operated by the Power Reactor Development Company (PRDC). This LMFBR demonstration plant was the first of the only two U.S. fast reactors that have been licensed to operate (the other being SEFOR). The PRDC applied for and obtained a license under Section 104b of the Atomic Energy Act of 1954. For purposes of the licensing of FERMI-1, the maximum "credible" accident was deemed to be the melting of fuel in one subassembly. The Applicants stated:

> As a result of the care given to basic safety, both in design and in the planning for operation, it is believed that no credible equipment failure can lead to melting of fuel. However, melting of some fuel in local areas of the core, specifically in one subassembly, cannot be entirely precluded. Such melting could occur due either to plugging of a subassembly nozzle despite the care which has been taken to keep the system clean, or due to inadvertent recycling of a core subassembly . . .

Enrico Fermi Atomic Power Plant, Power Reactor Devlopment Co., "Technical Information and Hazards Summary Report," Part B, Section VI, Evaluation of Hazards, Revised License Application, AEC Docket No. 50-16, July 24, 1961, p. 602.1, 603.1.

Despite this, on October 5, 1966, during a slow increase in power, fuel melting occurred in the Fermi core. Seven subassemblies were removed and inspected after the accident. Melting had occurred in two subassemblies; two additional subassemblies had been overheated. It is generally believed that the inlet nozzles of four adjacent subassemblies had been partially blocked by debris.

The next fast reactor to be built was the Southwest Experimental Fast Oxide Reactor (SEFOR), owned by the General Electric Company and located in Washington County, Arkansas. The average population within a 15 mile radius of the plant was about ten (10) people per square mile. Southwest Experimental Fast Oxide Reactor, Docket No. 50-231, Supplemental Safety Evaluation, Aug. 19, 1969, p. 2. SEFOR was designed to operate at a steady state power level of 20 MWt or to be subjected, in an experimental program, to power excursions produced by rapid ejection of a neutron absorbing slug. Id. at 3.

The design basis accident for SEFOR was "core collapse," postulated to result from an extreme overpower condition. Id. at 10. A maximum reactivity insertion rate was calculated ($50/second) and then total energy for the accident was "conservatively calculated" to be 830 MW-sec, 230 of which would appear as energy in vaporized fuel. The AEC staff concluding that the "theoretical upper limit of the energy available as kinetic energy is 100 MW-sec," as opposed to GE's estimate that the "actual" available kinetic energy would be less than 20 MW-sec. Id. The containment "design basis energy release" was 400 MW-sec, far less than the upper limit calculated. Thus, a CDA was a design basis accident for SEFOR and the containment was designed to withstand the maximum calculated explosion with conservative safety margins.

The Fast Flux Test Facility ("FFTF"), located at the Hanford Reservation, Washington, followed SEFOR. FFTF is a three-loop sodium-cooled 400 MWt fast neutron test reactor. FFTF was not subject to licensing since it is a DOE-owned test facility. However, it was reviewed by the AEC regulatory Staff which prepared a Safety Evaluation. Safety Evaluation of the Fast Flux Test Facility, Project No. 448, U.S.A.E.C., Directorate of Licensing, October 31, 1972; Supplement No. 1, Dec. 13, 1974; Supplement No. 2, March 7, 1975.

It is apparent from review of the Safety Evaluation that a core disruptive accident was understood by the AEC Regulatory Staff to be appropriately considered as within the design basis for the FFTF. The Accident Analysis section of the Safety

Evaluation judged the adequacy of the design against accidents involving gross fuel melting, sudden energy release and interference with core cooling. While noting that the postulation of such conditions requires assuming initial conditions together with a failure to scram, the assumption was termed "justifiable considering present lack of sufficient experience with which to quantify the chances of such a failure in a fast reactor system." Id. at 92.

The capabilities of the FFTF "safety related features" were evaluated against two particular postulated accidents: a loss of coolant flow without scram and a continuous reactivity insertion without scram (severe transient overpower). Id. at 93. In 1972, the Regulatory Staff estimated using conservative[3] assumptions that the maximum theoretical work energy released by such a CDA would be near 350 MW-sec. Id., Supplement No. 1, at 4. The effects of such an explosion on the containment, reactor vessel, and primary coolant system components were evaluated. While the Regulatory Staff concluded that the vessel and primary coolant system could withstand the postulated CDAs, they could not reach that conclusion with respect to the containment and, in fact recommended that "design flexibility" be retained for future installation of a core catcher. Id. at 136. Since FFTF did not have to be licensed, the Regulatory Staff's analysis was couched in the form of opinions, conclusions, or recommendations.

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[3] The Staff consistently maintained the position that it was "prudent to retain substantial conservatism in the evaluation" of both types of postulated accidents. Id. at 102, 104.

Regarding the potential for a CDA, the Regulatory Staff concluded:

> While we are of the opinion that a core disruptive accident will be of low probability, currently unquantified, we are not in agreement that the state of technology and experience on LMFBR systems is sufficient to establish that there is "no realistic potential" or that such accidents are precluded. We have therefore concentrated our review on the aspects related to the adequacy of in-vessel post accident heat removal.

Id., Supplement No. 2, at 1-1.

FFTF was built without a core catcher. After it became clear to the Regulatory Staff that the core catcher option was no longer viable, the Staff recommended that an emergency plan be implemented "to alleviate the potentially high doses associated with vessel meltthrough." Id., Supplement No. 2, at 1-5, 3-3, and 3-4.

In its 1978 Safety Evaluation Report on FFTF the NRC Staff stated:

> We have concluded that the risks associated with low probability reactor vessel melt-through are acceptably low assuming that a reasonable degree of containment integrity is maintained.

U.S. NRC, "Safety Evaluation Report related to operation of Fast Flux Test Facility," NUREG-0358, August 1978, p. 15-1. And as late as 1979 the Staff was still not endorsing full power operations:

> The Staff will not endorse continued operation of the FFTF beyond startup and natural convection testing without adequate measures being in place to augment existing containment margins and control radiological releases from a low probability core melt-through accident.

Id., Supplement No. 1, May 1979, p. 19-2.

In summary, of the U.S. fast reactors of significant size, core disruptive accidents were design basis events or their equivalent for EBR-II, SEFOR, and FFTF, or three out of four. Ironically, FERMI-1, the only one of the four which excluded accidents involving more than the melting of one subassembly on the grounds that such events were incredible, in fact experienced an accident greater than its design basis.

While our access to the details of design of foreign fast reactors is limited, the available evidence is that core disruptive accidents are design basis events in at least two plants under construction. The CDA is within the design basis for Super Phenix, a 3000 MWt pool-type fast reactor. It was licensed for construction by the French government in 1977. Super Phenix was required to contain 800 Mj of energy. Because of that requirement, a "cupola" or dome inside containment was incorporated into the design. Its molten fuel recovery system ("core catcher") is designed to take into account the possibility of a meltdown of 7 fuel assemblies. H. Noel and H. Frestone, "Safety Measures at the Creys-Malville Power Station." These two devices, the dome and molten fuel recovery system, are similar to the sealed head access area and core catcher that were incorporated into the CRBR parallel design where the CDA was a DBA.

Core disruptive accidents are also within the design basis of SNR-300, the German fast reactor, which is being built with a core catcher. I am unable to determine whether this pattern holds true for other foreign fast reactors.

Finally, core disruptive accidents were within the design basis for CRBR until the letter of May 6, 1976, from Richard P. Denise of the NRC to Lochlin W. Caffey, Director of the CRBR Project Office, declaring that the Staff had reversed its position:

> It is our current position that the probability of core melt and disruptive accidents can and must be reduced to a sufficiently low level to justify their exclusion from the design basis accident spectrum. We will therefore not consider CDAs as design basis accidents.

It is instructive to consider some of the history of the CRBR application because it establishes that core disruptive accidents cannot justifiably be excluded from the CRBR design basis without detailed, design-specific analysis of the CRBR.

On July 3, 1974, and on October 21, 1974, Richard P. Denise, AEC's Assistant Director for Advanced Reactors, wrote to Peter S. Van Nort, the General Manager of the Project Management Corporation, stating that CDAs should be in the design basis:

> Specifically, it is our current view that the plant should be designed on the basis that it will accommodate CDA's, and that CDA's specific to the CRBRP should be analyzed to form the design basis for the CRBR Plant.

Letter Richard P. Denise to Peter S. Van Nort, Oct. 21, 1974.

On November 1, 1974, Robert Bernero, then Project Manager of the LMFBR Branch under the AEC's Directorate of Licensing, and who now holds the position of Director, Division of Risk Analysis, Office of Nuclear Reactor Research, testified before the ACRS on the CRBR construction permit application. He began by explaining that the Staff reviews safety by setting design

basis accidents for the particular plant in question. He then outlined the two possible approaches for CRBR:

> Now, with respect to the CRBRP, there are two approaches with respect to this most important consideration of core disruptive accidents.
>
> You can preclude -- you might preclude core disruption if you are confident that you can have reliable analysis of the events that tend to seed or lead up to core disruption, and the mechanics are [or] the actions which take place during it. If you have confidence that you can reliably sense those events in a timely fashion. And, of course, if you have reliable action to prevent them, that you can make a shutdown system work in time, and a heat removal system follow-on as needed. That would be one approach.
>
> The other approach is to design for core disruptive accidents, still striving to prevent them. This does not remove the obligation to prevent core destruction. You are still trying to prevent them. But you incorporate design features to cope with them.

Transcript, Meeting of the Advisory Committee on Reactor Safeguards, Nov. 1, 1974, p. 367-368.

Mr. Bernero went on to state that core disruption could not then be precluded, precisely because the reliability of the CRBR systems used to prevent CDAs was not demonstrated:

> Now, as we have said, from what we have seen and what we have heard and what the Regulatory Staff knows of LMFBR technology at this time, we don't think it is reasonable to assume that you can preclude or sufficiently prevent core disruption. And we point out that it's more than scram reliability. That is one phase of the three general phases I indicated.
>
> The first and most important is the reliable [reliability] analysis. And basically, if you look at an unavailability or a probability of loss of coolable geometry as the Applicant prefers to say, one has to assign numbers all along to the analytical reliability and those later considerations.
>
> We feel that the LMFBR technology has a certain lack of sound experience of in-pile test experience, a lack of maturity of technology which makes perclusion of CDA or prevention to the likelihood to be likely to be next to impossible.

Id. at 368.

Applicants continued to press for precluding CDAs. In order to get the review of the CRBR application underway, the Staff agreed to review two separate designs at once, one which included CDAs as design basis, the other which excluded them. Letter from A. Giambusso, Deputy Director for Reactor Projects to Peter S. Van Nort, General Manager, Project Management Corporation, Nov. 19, 1974.

On December 6, 1974, Mr. Denise again wrote to Mr. Van Nort, this time outlining the critical weakness in the Applicants' position on CDAs, to wit: they continued to be unable to demonstrate that the CRBR safety systems would reliably sense and prevent all conditions leading to core disruption. The Staff was asking specific questions and getting only generalities in response.

Denise observes that the Applicants "proposed to establish that safe shutdown could be assured with sufficient reliability tha core disruptive accidents (CDA) need not be considered in the design basis." Id. at 1. He notes that the Staff has "frequently stated the position that we currently believe that CDAs should be included in the spectrum of design basis accidents." Id.

Denise proceeds to describe the Applicants' case:

> [T]he tone and content of the materials furnished suggest that you are treating the CRBRP like a light water reactor, i.e., simply as a Category A plant as defined in WASH-1270 (Anticipated Transients Without Scram for Water-Cooled Power Reactors). The specific evaluations and conclusions of WASH-1270 indeed apply only to light

> water reactors, and specific Regulatory positions in WASH-1270 are based on the level of operating experience and analytical understanding prevalent for light water reactors. In the case of the CRBRP, it is necessary to consider methodically all anticipated transient events, as well as low probability events which could involve core disruption, and to determine how these events are sensed in a timely way, and the specific role of shutdown action in limiting damage or preventing core disruption. From such considerations the design bases of the scram system and others are derived. It is not now evident tha these design bases for CRBRP will be very similar to the design bases appropriate to a water reactor system, which your draft materials for this meeting seem to assume. Scram reliability requirements can be appraised properly only in the context of knowing the specific function required of the scram action. For example, if it has not been established that transients which are to be considered will not progress irrevocably to core disruption in a few hundred milliseconds, it would be fruitless to argue the reliablity of a scram system which takes 1-2 seconds to function.

Id. at 2, emphasis added.

On June 5, 1975, the Staff wrote again to the CRBR Project General Manager, noting that "[t]he safety review of the CRBRP is complicated by the lack of resolution of a very basic issue, that is, whether core disruptive accidents (CDA) should be treated as design basis events,"[4] and reasserting the Staff's position that they should be. The Staff informed PMC that because of the large number of computer codes cited in the PSAR and other PSAR references not previously reviewed by the Staff, "special attention and arrangements will be necessary to provide acceptable documentation and review" of the codes and

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[4] A. Giambusso, Director, Division of Reactor Licensing to Peter S. Van Nort, General Manager, Project Management Corporation, June 5, 1975, p. 1.

references. Id. at 3. The Staff enclosed over 100 pages of detailed questions seeking the specifics of the CRBR design and the factual bases for Applicants' assertions concerning the reliability of CRBR systems.

At least as late as April 1, 1976, the Staff was still acting on the apparent presumption that the CDA should be within the CRBR design basis. The Staff informed PMC: "[W]e are of the opinion that a sufficient basis does not exist to accept the project's best estimate assessment of some of the CDA parameters and their contributions to the accident energetics."[5] Complaining of "the lack of design information," the Staff notified PMC that additional detailed reviews would be required of the Applicants' CDA analysis.

One month later, on May 6, 1976, Mr. Denise announced a dramatic reversal in the Staff's position. Prior to the Denise letter, the position consistently expressed by the Staff had been (1) CDAs should be included within the design basis for the CRBR unless and until applicants could demonstrate, by analyses of the specific CRBR systems, that those systems relied upon to prevent CDAs were sufficiently reliable to justify the assumption that CDAs would be precluded; (2) because the CRBR design is so different from LWR designs, and because of the lack of experience with fast reactors similar to CRBR, the assertion that the CRBR would meet LWR general design criteria or equivalent is not

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[5] Memo, P. Speis, Chief, Liqud Metal Fast Breeder Reactors Branch, to Peter S. Van Nort, General Manager, Project Management Corporation, April 1, 1976, p. 1.

sufficient to establish that the CRBR safety systems meet the required level of reliability to preclude CDAs; (3) the Applicants showing to date, which included the so-called Reliability Program, an integral part of Applicants' systematic approach using reliability methodology to select the limiting design basis for CRBR, did not justify excluding CDAs from the design basis.

Then, on May 6, 1976, the NRC Staff informed the Applicants of their "current position that the probability of core melt and disruptive accidents can and must be reduced to a sufficiently low level to justify their exclusion from the design basis accident spectrum."[6] The Staff stated that the following "minimum features and characteristics ... are necessary" for CRBR to prevent CDAs:

1. At least two independent, diverse and functionally redundant reactor shutdown systems;
2. At least two independent, diverse and functionally redundant decay heat removal systems;
3. Means to detect and cope with subassembly faults;
4. Either a heat transport system of very high integrity or protective features to cope with pipe failures;
5. Protection of the containment systems against the effects of sodium releases in the equipment cells.

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[6] Richard P. Denise, Assistant Director for Special Projects, NRC, to Lochlin W. Caffey, Director, CRBR Project Office, reproduced at NUREG-0139, Final Environmental Statement Related to Construction and Operation of Clinch River Breeder Reactor Plant, Feb. 19797, p. I-2, I-4.

The letter also stated that the Staff would use as a "safety objective that there be no greater than one chance in one million per year for potential consequences greater than the 10 CFR 100 dose guidelines ...". This was characterized as a "design objective rather than a fixed number which must be demonstrated...".

Mr. Denise's phrase -- that the probability of CDAs "can and must" be reduced to a level justifying exclusion from the design basis -- is a curious one. There is no explanation offered for the conclusion that CDAs "must" be excluded, although one could infer from other sources that the CRBR would not be licensed if CDAs were included within the design basis, hence they "must" be excluded.

As to the assertion, more accurately characterized as a hypothesis, that CDAs "can" be excluded, one searches the record in vain for support for this fundamental change in position. The fact is that the Applicants had been trying for at least two years to demonstrate that the CRBR systems would achieve a level of reliability sufficent to justify the assumption that CDAs were incredible; they had failed to make that demonstration. Confronted with a design which could not then be approved on the basis of the available specific design information, the Staff retreated to the level of generalities. Against the background of the CRBR review to that date, I believe that the Staff position as of May 6, 1976, can fairly be interpreted as follows: (1) the CRBR could not be licensed unless CDAs were excluded from the design basis; (2) the available design-specific

information and analysis did not make a case for concluding that CDAs are incredible for the CRBR; (3) some other hypothetical design including at least the "minimum" features described above could justify excluding CDAs.

It is extremely important to note that the proposition that CDAs "can" be excluded is a hypothesis and not a fact. The Denise letter neither referenced nor contained any analyses to support the conclusion that a design containing the minimum features described therein either had been or could be shown to meet or even "adequately approach" the safety objective of ensuring that the probability of exceeding 10 CFR Part 100 guidelines was no greater than 1×10^{-6} per year of operation. Thus, Denise's statement that the probability of CDAs "can" be made sufficently low is at best a hypothesis for which Denise provided no apparent factual support.

The CRBR Project was placed into limbo by the determination of President Carter in the Spring of 1977 that its continuation was not in the national interest. All licensing activities were halted for over four years. When they resumed, Applicants applied for a limited work authorization (LWA).

There is a disjunction between the initial CRBR licensing review in the mid-1970s and the current review for at least two reasons. First, the group of NRC Staff members assembled to work on the current review is almost without exception new to the CRBR. None of the senior Staff responsible for the CRBR review are personally cognizant of the history of the CRBR application and none was able during depositions to articulate a factual

basis for the statement in the Denise letter that the probability of CDAs "can" be made sufficently low.

Moreover, neither could the Staff justify its exclusion of CDAs to the ACRS:

> MR. MARK: What we are saying is we have to understand something about the progress of such an event. We have not been quite able to decide whether it is a design-bases event or not a design-basis event. We have not been able to decide whether it is a likely event or an unlikely event. But we have decided that we must understand it.
>
> We are going to have to face up, however, at some point to the extent to which we insist that this event be prepared for in the design. Is it or is it not design basis?
>
> . . . .
>
> MR. CHECK: ... While I am not the ultimate historian, I think it has never really been classified as a design basis event. It has skirted it; it has come close. I think we are prepared to say that it is not a design-basis event without being able to prove that today, without wishing to make that case today.

Transcript, Meeting of ACRS Subcommittee on CRBR, May 5, 1982, p. 381-382, emphasis added.

There is a second disjunction not unrelated to the first. The initial CRBR safety review focussed on the specifics of the CRBR design. The current review, at least insofar as the LWA is concerned, does not. Paul Check, who holds the title of Director, CRBR Program Office, and is currently the senior NRC Staff member for the CRBR review, stated to the Advisory Committee on Reactor Safeguards:

> MR. CHECK: I am trying to string together a history and some rationalization for a logical approach to this which, quite frankly, is aimed at describing that minimum, tha minimum that we must do for LWA-1 purposes. ... [W]e are re-examining what was done before and seeing if we can do less

and still meet responsibilty requirements for LWA-1 findings.

Transcript, Meeting of the ACRS Subcommittee on CRBR, March 31, 1982, p. 123-124. In the terminology of the NRC rules, the focus of review has changed from analysis of the CRBR to discussion of a reactor "of the general size and type." The ACRS experienced great difficulty with this approach:

> MR. CARBON: But as a point of clarification here, this is a site suitability meeting to discuss this site for a reactor of this type and size, as you said, and CRBR may or may not fit the site.
>
> MR. CHECK: That is true. That is true.
>
> MR. OKRENT: I must say I find the discussion of a site suitability report for a reactor of this size and type, not necessarily CRBR, to be a sort of fantasy. There is one reactor people have in mind building there. It is CRBR, within whatever modest modifications are practical at this stage and, you know, we ought to stop pretending.

The following portion of this testimony will examine each of the ways in which a decision-maker could seek confidence that the probability of an accident beyond the CRBR design basis is so remote as to be incredible for a reactor of the general size and type of the CRBR and will conclude that there is not sufficient basis for that conclusion.

II. THERE IS NO EMPIRICAL EVIDENCE TO SUPPORT THE PROPOSITION THAT, FOR A REACTOR OF THE GENERAL SIZE AND TYPE AS CRBR, THE PROBABILITY OF A CDA CAN BE MADE SUFFICIENTLY LOW TO JUSTIFY EXCLUDING IT FROM THE DESIGN BASIS FOR CRBR.

In order to determine whether the probability of CDAs "can" be made sufficiently low to justify their exclusion from the CRBR design basis, one should begin with a definition of "sufficiently low." As noted supra at 4, the 1977 FES established the goal in numerical terms. This can also be found in the Denise letter which contains the same "safety objective" that "there be no greater than one chance in a million per year for potential consequences greater that the 10 CFR 100 dose guidelines for an individual plant, for example CRBR ...". While this is stated to be a "design objective" rather than a "fixed number which must be demonstrated," the operative meaning of that distinction is unclear except perhaps to indicate flexibility in the degree or nature of the evidence required to demonstrate that the objective has been met. Nonetheless, if the "objective" is that the probability of exceeding Part 100 shall be no greater than 10^{-6} per year, then it is fair to use that objective as a definition of "sufficiently low" probability.

It should also be noted here that, while the objective is stated in terms of the probability of exceeding the Part 100 guidelines, for the purposes of this stage of the proceeding, compliance with that objective requires showing that the probability of initiating a CDA is less than 10^{-6} per year. My reasoning is as follows: The probability of exceeding Part 100 guidelines is the product of two probabilities -- the probability of initiating a CDA times the conditional probability that, given

the initiation of a CDA, it will result in doses exceeding the 10 CFR 100 guidelines. The conditional probabilty that the CDA, if initiated, will exceed 10 CFR 100 dose guidelines is design-specific, partly a function of the reliability of the CRBR containment systems, which are intended to "accommodate" CDAs. Allocation of a value substantially less than 1 to this conditional probability involves a level of design-specific review which has not been presented by the Staff and requires design-specific information which goes far beyond "the general characteristics of the CRBRP design (e.g., redundant, diverse shutdown system)" that limits the scope of this proceeding. Order Following Conference With Parties, April 22, 1982 at 2-3. Indeed, the Applicants' so-called "reliability program," which included the elements required to establish the reliability of the CRBR containment systems and components (e.g., data collection, testing, fault tree and event tree analysis, failure mode and effects analysis, and common mode faiure analysis), was the subject of NRDC Contention 1(b) and was ruled beyond the scope of this stage of the proceeding. Since there is no basis for determining the conditional reliability of the containment systems, a conditional probability of CDA progression cannot be established.

Moreover, analysis of the progression of CDAs involves the computer modelling of the behavior of the reactor core after the onset of core disruption. The computer codes used to do that modeling are enormously complex and contain literally thousands of assumptions. The results are strongly design specific. They

have also been ruled outside the scope of this proceeding. Tr. 551-552, Prehearing Conference of April 20, 1982.

And finally, because both Applicants and Staff contend that they do not rely on any analysis of the progression of a CDA, once initiated, or any probabilistic risk assessment of this conditional probability for determining that the CDA is beyond the DBA envelope, there is no basis for assignment of a value to the conditional probability that is less than 1.

In sum, since the factual predicates necessary for establishing the conditional probability of CDA progression will not be considered, no credit can be taken for the conditional probability on the basis of the available information. That is, no credit can be taken for the improbability of conditions relating to remaining plant containment and site features. One must assume, therefore, that the overall goal of less than 10^{-6} probability per year for exceeding 10 CFR guidelines must be met for the probability of loss of core coolable geometry, i.e., the probability of initiation of a CDA. This is precisely the approach taken by the Applicants in their Reliability Program in 1976.[7]

Having established a goal for the probability of loss of coolable geometry, the next step is to examine alternative ways to test whether the probability of a CDA in a reactor of the general size and type of CRBR meets the goal.

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[7] Applicants noted at the time that, "The conservatism inherent in establishing this requirement ensures compliance with 10 CFR 100.2 which specifies that 'novel reactors' are expected to use criteria which 'takes into account lack of experience.'" Clinch River Breeder Reactor Project, Reliability Program, January 1976, p. 12.

° First, one might argue that the best evidence should derive from a detailed analysis of the CRBR itself.

° Second, one could ask whether a reactor substantially similar to the CRBR has been licensed.

° Third, one could ask whether the features of the CRBR which are asserted to prevent CDAs are substantially the same as the features of any other reactors that have been licensed pursuant to the same criteria as those applicable to the CRBR.

° Fourth, one could ask if a set of detailed design criteria have been established and justified that, if met, would ensure that the probability of a CDA is less than 10^{-6} per year.

I will go through these approaches seriatum.

Case 1

The first approach can be dealt with summarily, in that the specifics of the CRBR design, beyond its "general design characteristics," are excluded from the LWA-1 inquiry.

Case 2

With regard to the second approach, if, during the licensing of a reactor substantially similar to the CRBR, it was demonstrated through design-specific analyses that the probability of CDA initiation was less than 10^{-6} per year, one could have confidence that a CDA can be excluded for a reactor of the general size and type of CRBR.

This second approach also can be dealt with summarily. No reactor substantially the same as the CRBR has been licensed. The Staff and Applicants can point to no analysis that demonstrated that, for a substantially similar fast reactor, the

probability of a CDA was sufficently low to justify its exclusion from the design basis.

While the Staff provides two paragraphs discussing the "experience" with fast reactors, that experience is scant indeed, as is the information provided. NUREG-0786, Site Suitability Report in the Matter of the Clinch River Breeder Reactor Plant, Revision to March 4, 1977, Report, p. II-3 - II-4. The Staff does not even discuss the highly pertinent information of whether CDAs were inside or outside the design basis for the fast reactors mentioned, nor how that decision was made and justified. The most that can be concluded from this experience is that some fast reactors, none of which is substantially similar to a reactor of the general size and type as CRBR, have operated. Most were unlicensed. Two have experienced core melt beyond the CRBR design basis. For at least some, CDAs were within the design basis. This "experience" does not support any particular conclusion with regard to the probability of a CDA for a reactor of the general size and type of the CRBR, much less the conclusion that such probability is "sufficiently low" or no greater than 10^{-6} per year.

The foreign experience is, if anything, even less supportive of the conclusion. For one thing, the Staff again fails to tell us whether CDAs are inside or outside the design basis for these foreign reactors, nor what the licensing criteria were for these facilities, if they were licensed. None of the foreign reactors are substantially similar to CRBR. CDAs <u>are</u> within the design basis of at least Super Phenix and SNR-300. Once again, this

"experience" amounts to little more than that fast breeders have operated abroad, at times with substantial difficulties. The fact that a breeder will work does not lead one to conclude that it will not have a core disruptive accident. TMI-2 worked before it had a core disruptive accident. Moreover, the Staff does not systematically review foreign reactor experience and thus can hardly base judgments as to the adequacy of the CRBR design on such experience.

In conclusion, use of the ~~first~~ second approach outlined above does not provide confidence that the probability of a CDA for a reactor of the general size and type of CRBR is sufficiently low to justify its exclusion from the design basis.

Case 3

Therefore, I go on to the third approach, asking whether the features of the CRBR that are asserted to prevent CDAs are substantially the same as features of other reactors that have been licensed using criteria applicable to the CRBR. That is, have substantially similar features been incorporated into previous plants, and, if so, has their reliability been demonstrated to be so high that CDAs can be treated as incredible? This corresponds to the general approach used primarily by the Staff.

The four general design features which are asserted to prevent CDAs are discussed at pages II-6 through II-13 of NUREG-0786, the Site Suitability Report of June 1982. They are the reactor shutdown system, piping integrity, fuel failure propagation, and residual heat removal.

It is instructive to examine the reactor shutdown system in this regard, in that it is here that the design features are perhaps most similar to the comparable systems of an LWR and consequently one would anticipate that it is here that the Staff's (and Applicants') case could be more easily made.

There are several questions that come immediately to mind in comparing the two (CRBR and LWR) shutdown systems:

(1) What is the reliability of LWR shutdown systems, and do they meet the criterion established for such systems?

According to the Proposed ATWS rule for LWRs (46 FR 57521, Nov. 24, 1981):

> There have been roughly one thousand reactor years of experience accumulated in foreign and domestic commercial light-water-cooled reactors without an ATWS accident. This experience suggests that the frequency of ATWS accidents is less than or of the order of once in a thousand reactor years. There have been several precursor events, i.e., faults detected that could have given rise to ATWS events. This suggests that the frequency of ATWS accidents, though less than once in a thousand reactor years, may not be very much less. Such frequencies are too high for accidents of the severity described above. Thus the NRC has determined that reductions must be made in the frequency, severity or both the frequency and severity of ATWS accidents.

46 FR 57522, (Nov. 24, 1981) (emphasis supplied).

> The NRC has concluded that the reliability of current reactor protective systems has not been demonstrated to be adequate and most likely is not adequate.

Id. at 57523.

(2) Can LWR shutdown reliability deficiencies be adequately corrected by modification of the reliability of the protective system alone,, i.e., the control rods and control rod drives, or must other LWR design-specific improvements be made?

All alternatives under active consideration under the proposed ATWS rule require some LWR design-specific measures to mitigate ATWS events which are not directly transferable to LMFBRs, e.g., providing actuation circuitry that is separate from the reactor protection systemm for primary system relief values and auxiliary feedwater.

(3) Even if LWR shutdown systems could be demonstrated to be adequate for LWRs, would their level of reliabilty be adequate for the CRBR?

The answer is no. It has been long recognized that because of the differences in severity of ATWS events (see discussion at p. 9-10 above), the reliability of LMFBR shutdown systems must be higher than that for a LWR, hence the emphasis on redundancy, diversity, and independence of the two CRBR shutdown systems. Moreover, because of the significant differences in the other plant safety features (e.g., lack of ECCS in LMFBR and lack of intermediate sodium loop in LWR) and the difference in ATWS event sequences, consequences, and performance criteria and because these are often highly design-specific, it is impossible to establish the reliability of a CRBR shutdown system relative to that of the LWR without a comprehensive probabilistic risk assessment. (Such analyses are excluded from the scope of the LWA-1.)

In this regard, it is instructive to examine the following exchange between ACRS members and Applicants:

> MR. KASTENBERG: I'll give you another example. For some other reactors they are predicting or they are calculating core melt with frequencies of 10^{-3}, 10^{-4} per year. If someone came to you and said,

ah, is that what you are shooting at for Clinch River, you might have a problem.

MR. CLARE: Okay. I am again not exactly sure what you are suggesting there. If you ask me if I am shooting for a probability of a core melt on the order of 10^{-3}, no, I don't think so.

MR. KASTENBERG: Or even 10^{-4}.

MR. CLARE: I think we understand the message that you would be concerned that we somehow tie ourselves too closely to the LWR which might serve inappropriately.

MR. KASTENBERG: Right.

MR. MARK: And drag in irrelevant boundary conditions.

MR. CLARE: Right.

MR. KASTENBERG: Exactly.

ACRS Transcripts, May 25, 1982, pp. 275-276.

It is also worth noting here that one of the major causes of uncertainty in WASH-1400 cited by the NRC's Risk Assessment Review Group (Lewis Report)[8] was the variations between reactors and the fact that WASH-1400 examined only one BWR and one PWR. There are substantially larger differences between the major safety systems, e.g., reactor shutdown systems, in a reactor of the general size and type as CRBR and those in LWRs than between systems in reactors of the same LWR type.

(4) Given that the CRBR will have two reactor shutdown systems with specific requirements regarding independence, diversity, and redundancy, can one conclude that their

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[8] H.W. Lewis, et al., "Risk Assessment Review Group Report to the U.S. Nuclear Regulatory Commission," NUREG/CR-0400, Sept. 1978, pp. 10-11.

reliability will be substantially improved over comparable LWR shutdown systems?

First, it should be noted that there is some "independence, diversity, and redundancy" built into LWR shutdown systems. The question arises: if we design for a greater degree of independence, diversity, and redundancy, can we determine whether the desired level is achieved -- in this case some 3-4 orders of magnitude improvement over existing LWR systems?

As stated in the proposed ATWS rule,

> [T]he very high level of reliability required is difficult to demonstrate with confidence because it depends on accurately determining the rate of common cause failures. Common cause failures involve failures of multiple components resulting from a single cause or event. Reactor protection systems are carefully reviewed to identify and eliminate all but the most unlikely common cause failures. However, one common cause failure in the reactor trip portion of the protection system of a commercial nuclear power reactor has occurred during approximately 1000 reactor-years of operating experience. The failure was detected during normal surveillance and corrected before any event requiring a reactor scram occurred. There has also been one partial failure to scram in a commercial power reactor, which occurred at low power and resulted in no core damage or radiation release.
>
> Common cause failures have also occurred in other systems in nuclear power plants and other potential common cause failures in reactor protection systems have been identified. Because of the low rate of occurrence of common cause failures, operating experience is not, and cannot be, sufficient to conclusively determine on a statistical basis whether reactor protection systems are reliable enough to make the probability of unacceptable consequences from ATWS events acceptably small. The prediction of common cause failures is as much art as it is science. System reliability analyses that attempt to predict the nature and frequency of common cause failures suffer from problems of completeness and accuracy,particularly when the desired failure rate is extremely small.

46 FR 57522-23 (Nov. 24, 1981).

In sum, the answer is no, one cannot conclude that the reliability will be substantially better.

(5) Can common mode failures significantly impact CRBR shutdown system reliability?

According to Woodward and Baloh of Westinghouse Electric Corporation, the prime contractor for CRBR,

> common cause failures have the potential to significantly impact the ability of an entire safety system to function when required.
>
> ....
>
> Because of the large number of potential common causative factors that are conceivable, an essential part of the CCF evaluation process is to identify and focus attention on those factors which may have the potential to produce failures having significant consequences. Two basic sources of information are used to achieve this objective:
>
> 1) Recent reactor operating and fabrication experience.
> 2) Detailed design evaluations which start at the component level, identify all failure modes and sorts them relative to their probability of occurrence and system consequences.

W.S. Woodward and F.J. Baloh, "Common Cause Failure Assessment Specification for the CRBRP Reactor Shutdown System," WARD-D-0195, March 1978, p. 1-1 - 1-2 (emphasis supplied).

An extensive list of common causative factor categories is provided in Table 2-1 on p. 2-7 of the Westinghouse assessment. Id. at 2-7. The list of individual events would be far more numerous. Woodward and Baloh also observe:

> Historically, significant common cause failures have occurred, as a result of unidentified dependencies which exist between components or systems.

(Id. at 2-5) and

> Although the human factor is only one of the many common causative factors identified ... experience has shown it to have a major influence on common cause failures

(Id. at 2-6) Also,

> The survey of past reactor experience indicates that the majority of CCF related incidents can be traced to human factors. Inferior components that escape proper inspection, installation errors, inadequate operational procedures and negligence contributed to more than 60% of the surveyed incidents.

Id. at p. 3-6.

The Report of the Reactor Safety Review Group (September 1981) found that:

> Most studies of the likely causes of serious accidents conclude through probailistic risk analysis that over 50% of the risk is associated with human failure to perform as intended.

Harold Denton, Director of NRC Office of Nuclear Reactor Regulation, copy of viewgraph enclosed in letter from Richard Shikiar to Thomas Cochran, Jan. 27, 1982.

As noted above, common mode failure analysis requires "detailed design analysis." Potential common cause failures for the CRBR are to be identified and assessed as part of the CRBR Reliability Program.[9] The adequacy of this program was the subject of Intervenors Contention 1(b), which under the Board's order is outside the scope of the LWA-1.

It is also instructive to note that the NRC Staff has made no assessment of the probability of accident sequences within or

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[9] Id. at p. 1-1.

beyond the design basis as can be seen from the following exchange between the ACRS and the Staff:

> MR. MARK: I mean if it [hypothetical core disruption] were a small enough frequency, then our interests might be low enough; if it is a high frequency, then our interest should be very intense. What is it?
>
> MR. ALLEN: Okay. My response to that is, of course, the Staff is requiring that the core-disruptive accident be maintained at a low enough probability that it remains outside the design basis envelope. And on those grounds, we intend to proceed with our review ....
>
> I do not have a probabilistic number I would feel comfortable with. All I can state is that that is the requirement: that it be kept low enough by assuring capability of the plant protection system to guarantee that.

ACRS Transcripts, May 5, 1982, p. 379. See also, ACRS Transcripts, May 24, 1982, p. 211.

In sum, there is no demonstration by the Staff that it is feasible to design CRBR shutdown systems with a failure rate significantly less than that for LWRs, which is estimated to be approximately 10^{-3} per year. As I have indicated above, to exclude the CDA from the design basis without establishing the conditional probability that a CDA once initiated will exceed Part 100 guidelines, there must be a showing that the failure rate of the CRBR shutdown systems can be substantially (an order of magnitude) better than the goal of 10^{-6} per year. The present state of the art is orders of magnitude away from approaching that goal.

I have used the example of the shutdown systems to illustrate that one cannot conclude, based upon the general descriptions of the systems intended to prevent CDAs, that CDAs

will not occur. The primary point to keep in mind is that, despite the NRC's requirements for redundancy, diversity, and independence, all systems and all components have some rate of failure and that those failure rates are to a substantial degree design-specific. The systems designed to prevent CDAs will not work perfectly. In addition, humans will make errors in the design, testing, surveillance, and operation of the systems, adding to the failure rate.

It is therefore not sufficient to state, as the Staff does, that the shutdown systems or the other systems intended to prevent CDAs will be "state of the art" without demonstrating what the reliability of the particular state of the art system is and without demonstrating that the reliability of that system in combination with the reliability of other systems (and their interaction), is sufficient to insure that CDAs are not credible. That is the missing link. One could conclude that it is "feasible" to design CRBR so that the systems intended to prevent CDAs are state of the art. That is not the same as concluding that it is feasible to design CRBR so that CDAs are incredible. The missing link is crucial: the evidence that state of the art systems for CRBR, or a reactor of the general size and type, are good enough to sense and prevent CDAs with a vanishingly small chance of failure.

At this point it is important to recall that Applicants are seeking to justify a decision that is unprecedented in U.S. licensing history: that CDAs can be considered incredible for a reactor of the general size and type of CRBR. If the evidence

does not support such a conclusion, as I firmly believe, the necessary consequence is not that an LMFBR cannot be built, but at the most that, if built, CDAs must be included within its design basis, as for Super Phenix, SNR-300, and the CRBR parallel design, for example.

To summarize, I posed the following question above: Have substantially similar features been incorporated into previous plants, and, if so, has their reliability been demonstrated to be so high that CDAs can be treated as incredible? Considering the Staff's Site Suitability Report, the answer to the first part of the question is "no." Most of the general CRBR features have some similarities to systems which have been used in LWRs. Some are almost completely different from previously licensed plants, as in the case of the systems being developed to prevent fuel failure propagation. All have significant differences. The answer to the second part of the question is also "no" for the reasons discussed above.

Case 4

I therefore proceed to the fourth approach outlined above, namely, whether a set of design criteria has been established and justified which, if met, would ensure that the probability of a CDA for a reactor of the general size and type as the CRBR is "sufficiently low," or no greater than 10^{-6} per year; and, could these criteria be met.

The answer to the first part of this question is "no."

There are no approved design criteria for judging the acceptability of the CRBR design, nor are there general design

criteria for fast reactors. The Applicants have proposed a set of broad and general criteria for CRBR (1982 SSR, Appendix A). The Staff's review of these criteria, its acceptance, rejection and/or modification of these criteria will not be set out until the SER is published.

The general principle behind these proposed criteria is apparently that they should achieve comparability between the risks associated with light water reactors ("LWR") and the risks associated with CRBR. However, there is no way of judging whether the criteria will accomplish that, since they have not been finalized, nor has an analysis been performed by the Staff to match the existing LWR criteria against the proposed CRBR criteria. As members of the ACRS have observed, the questions of which LWR criteria should apply to CRBR, which should be adapted and how that should be accomplished, and what new criteria should be established in areas not covered by the LWR criteria, are not simple ones. See generally, Transcript, March 30-31, 1982, Meeting of the ACRS Subcommittee on CRBR.

The following exchanges from the ACRS meeting of March 30, 1982, are instructive:

> MR. CARBON: ... There are several very important technical issues on which the principle design criteria are either silent or vague, and among these -- again, these are ones that I personally consider very important issues on the safety of the CRBR. One of these is the definition of design basis accident and the second is the role of CDA's and energetics. The third is the definition of the site suitability source term. Fourth is the margin of safety against seismic events. Fifth, the natural circulation decay heat removal requirement. Sixth, containment confinement considerations, including perhaps questions about vented containment. And seven, sabotage.

> Now, obviously some of those don't belong in design criteria, but if you would do as much as you can to relate the criteria to these issues and vice versa, I think it would be helpful to our understanding.

ACRS Transcripts, March 30, 1982, p. 5. Even the NRC Staff maintains that the CRBR Design Criteria are subject to further revision:

> MR. CHECK: ... He [Bill Morris, NRC Staff) pointed out that the process for developing and improving the principle design criteria is in large measure a significant component of the construction permit review. ... as our [CP] review matures and the development of the principle design criteria progresses.

ACRS Transcripts, March 30, 1982, p. 11.

It is also important to note that the criteria by which CRBR is supposedly to be judged are being developed at the same time that the design for the plant is being finalized, and apparently on the basis of the plant's design rather than vice versa. As ACRS Subcommittee member Myron Bender stated, "I think your timing is wrong. I think you have to get [the design criteria] out before you put it in the SER." Id. at 31. "[T]here's no basis for judging unless you put the judgment criteria out before you present your case." Id. at 33.

Both the Staff and the ACRS Subcommittee Chairman Max Carbon acknowledged that the way the criteria were being developed raised questions as to their meaningfulness when he remarked.

> [W]e have to be sure that these are viewed as standards by which CRBR is judged, rather than -- I think his words were something along the lines of prepared to help justify what we are doing.

Id. at 63.

Moreover, there is no basis for the choices of the principal design criteria which have been proposed by Applicants and are being considered by Staff. This omission has also been noted by the ACRS:

> The criteria are kind of bald right now. They just say, here are the criteria. But why they are criteria leaves a lot to the imagination, and while I am very comfortable with what I understand about LWRs, I do not think I have any reason to believe that anybody here should have less discomfort than me with the question of whether I understand why LMFBRs have certain criteria.

Id. at 64 (remarks of Mr. Bender). Once again, Staff responded that it would defend its choice of criteria only when it issues its SER. Id. at 65.

In its letter of July 13, 1982, to the Commission, the ACRS provided its present position regarding the CRBR Design Criteria:

> ... at the [CRBR] construction permit stage substantive assurance will be needed [to assure] that such criteria are being met. We wish to note that we do not necessarily agree with all the LMFBR Design Criteria specified in Appendix A of NUREG-0786.

Letter from P. Shewmon, Chairman, ACRS, to Nunzio J. Palladino, Chairman, NRC, "ACRS Report on the Suitability of the Clinch River Breeder Reactor Plant Site," July 13, 1982.[10]

Finally, it should be noted that Applicants and Staff alike do not rely on the sufficiency or completeness of CRBRP Design Criteria, the requirements set forth in the May 6, 1976, letter from Denise to Caffey, or any known set of criteria from any

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[10] The ACRS went on to conclude that the CRBR site would be suitable for a plant that would present no greater risk to the health and safety of the public than an LWR; however, no opinion was offered as to whether the CRBR meets this condition.

variety of sources as the basis for their own conclusions that a CDA can be excluded from the DBA. In fact, no such complete set of criteria is known to exist.

In sum, none of the four approaches considered above provides the necessary evidence to insure the CDA can be excluded from the DBA.

As noted above, Staff's case for excluding the CDA from the DBA is essentially the Case 3 above. Applicants' case is nothing more than a combination of aspects of Cases 1, 3, and 4. I will review it below.

Applicants' Case

Applicants' judgment that the likelihood of a CDA is so low that it can be excluded from the design basis is based on Applicants' understanding of their general approach to design (as described in PSAR 15.1.1), along with an understanding of conditions under which an HCDA can potentially be initiated, and an understanding of the plant features (as reflected in CRBRP-3, Vol. 1, Chapter 3) that are provided to "preclude" occurrence of CDAs, i.e., render to them a probability that is sufficiently low (Clare deposition, June 16, 1982, pp. 10-11, 35-37).

Applicants have made it clear[11] that they:

(1) do not rely upon the reliability program at all;

(2) do not know the probability of failure of the reactor shutdown systems or any of the general design features;

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[11] These assertions were all made in response to questions by NRDC at a deposition of Applicants' witnesses on June 16, 1982.

(3) do not rely upon tests of their shutdown or heat removal systems as a basis for their conclusion that CDAs are not DBAs;

(4) have not quantified the controlling reliability threshold criterion for excluding the CDA from the DBA;

(5) do not factor probabilistic risk assessments into their judgment that HCDA initiators are within or outside the design basis;

(6) have not used any analysis or evaluation of designs of plants other than CRBR in reaching conclusions regarding whether the CDA is within or outside the design basis;

(7) do not rely on the sufficiency or completeness of CRBRP Design Criteria, the requirements set forth in the May 6, 1976, letter from Denise to Caffey, or any known set of criteria from a variety of sources. No such complete set of criteria is known to exist;

(8) do not rely on any analysis of the HCDA once initiated.

Returning now to the general design approach which Applicants do rely on, Applicants claim this is set forth in Chapter 15.1.1 of the PSAR. Chapter 15.1.1 sets forth in the most general terms a safety approach that is nothing more than the familiar "defense-in-depth" approach characterized by "three levels of design emphasis" (PSAR, p. 15.1-1), namely attention to accident prevention, mitigation, and containment:

> The first level focuses on the reliability of operation and prevention of accidents through the intrinsic features of the design construction, and operation of the plant, including quality assurance, redundancy, testability, maintainabilty, and failsafe features of the components and systems of the entire plant.

> The second level focuses on the protection against "Anticipated Faults" and "Unlikely Faults" which might occur despite the care taken in design, construction, and operation of the plant set forth in level one above. This protection will ensure that the plant is placed in a safe condition following one of these faults.
>
> The third level focuses primarily on the determination of events to be classified as "Extremely Unlikely Faults" and their inclusion in the design basis. These faults are of low probability and no such events are expected to occur during the plant lifetime. Even though they represent extremely unlikely cases of failures, they will be analyzed to establish conservative design bases. In addition to these three levels of design, the CRBRP has included structural and thermal margins for accidents which are beyond the design base (see Section 15.1).

PSAR, pp. 15.1-1,-2.

Chapter 15.1.2 of the PSAR (which Applicants purport not to rely upon) sets forth the Applicants' proposed definitions of "anticipated faults," "unlikely faults," and "extremely unlikely faults" and the Applicants' proposed acceptance criteria for each of these categories (PSAR, p.15.1-53)

Nowhere in the PSAR is there a demonstration that this design philosophy (PSAR 15.1.1), alone or in combination with the event classification (PSAR 15.1.2) ensures that it is feasible to design a reactor of the general size and type as CRBR to make CDAs sufficiently improbable that they can therfore be excluded from the design basis envelope. Instead, what is presented here is simply a bald classification scheme with no justification for the selection of the design basis events.

One can readily see that the design philosophy itself does not logically dictate where the design basis line is drawn and does not provide the assurance that it is feasible to exclude the CDA from the DBA.

(1) The same three-level design philosophy was also applied by DOE (ERDA and AEC) to the FFTF and to the CRBRP parallel design, both of which included the CDA within the design basis.

For FFTF, the design philosophy was as follows:

> The first level of safety is the fundamentally safe reactor design to minimize the frequency of off-normal events. Accepted and conservative design practices assure adequate safety margins for all major systems and components, from the fuel pins to the reactor containment. Testing and inspection assure that all key systems are functional and operational. Extensive monitoring systems provide operator alarm for off-normal conditions.
> The second level of safety assumes reactor shutdown for any off-normal event threatening the reactor. Two independent shutdown systems are each capable of effecting reactor scram on multiple signals covering the spectrum of possible malfunctions. Each possible malfunction is protected by independent trip signals on the two shutdown systems.
> The third level of safety assures protection of the public even for extremely unlikely conditions and postulated failures of levels 1 and 2. Containment of radioactivity is provided by three successive barriers: the fuel pin cladding, the primary reactor system, and the reactor containment system. While certain off-normal conditions are expected in the lifetime of the reactor, such as random failures of a few fuel pins, no identified reactor malfunctions protected by the Plant Protection Systemm (PPS) result in breach of the fuel pin cladding due to the imposed transient. Only for complete failure of the shutdown systems do reactor incidents causing undercooling or overpower of the core threaten the cladding integrity. Analyses of the reactor response to a hypothetical loss of cooling or transient overpower events with failure to scram show that the second barrier to radioactivity release, the primary system, is expected to remain intact even for these extreme postulated combinations. Further analysis assuming an accident that causes leakage out of the primary reactor system shows that the third barrier, the containment building, effectively

retains the radioactivity and assures no significant health hazard to the public.[12]

As in the case of current CRBR safety approach, the third level of safety for FFTF dealt with the so-called "extremely low probability events" against which the containment margins were assessed. Unlike the present CRBR (Reference) design, however, the FFTF design basis, i.e., "extremely low probability" events included the HCDA.

The design philosophy and event classification scheme currently being applied to the CRBR (Reference) design was also applied to the CRBR Parallel design where "accidents involving loss of in-place coolable geometry were treated as design basis events" (PSAR, Amendment 5, Oct. 1975, p. Fl-l). This design included "certain parallel design options" which the Applicants at the time "judged capable of containing the consequences of a broad spectrum of highly improbable, conservatively specified and analyzed core disruptive accidents used as Design Basis Accidents" (PSAR Amendment 5, Oct. 1975, p. Fl-3). Likewise, the same proposed Clinch River Breeder Reactor Plant Design Criteria were applied to both the Parallel and the Reference designs.

In sum, the application of the safety design philosophy (PSAR, Chapter 15.1.1) and the proposed CRBRP Design Criteria do not insure the feasibility of excluding the CDA from the DBA. The fact that one can establish a general classification scheme

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[12] FFTF Final Safety Analysis Report, HEDL-TI-75001, Vol. 7, p. A.1-1 and A.1-2. See similar statements in Hanford Engineering Development Laboratory, "Fast Flux Test Facilty Design Safety Assessment," HEDL-TME 72-92, July 1972, pp. 1-1, 1-2, 3.1-1.

does not insure nor provide confidence that one can properly assign accidents to the respective categories. As history demonstrates, Applicants have used the very same categories and different accidents were assigned. Precisely the same safety philosophy applies whether the CDA is within or outside the DBA envelope. In each case, a judgment has been made; but in neither case does the classification scheme provide assurance that the judgment is correct.

What is necessary is a showing based on empirical or at least analytical evidence -- some defensible test of the hypothesis that the probability of a CDA can be made sufficiently low to justify its exclusion from the DBA.

This brings me to the heart of Applicants' case, namely the claim that it has systematically identified all CDA initiators and taken steps to protect against them.

Two questions must be addressed:

° First, can one have confidence that all important classes of initiators have been identified; and

° Second, is identification and protection of initiators a sufficient condition to insure the probability of a CDA is sufficiently low?

Both these questions must be answered affirmatively in order to exclude the CDA from the DBA.

With regard to the first question, it cannot be answered wtihout (a) a detailed analysis of the specific design, which is beyond the reach of the LWA-1 stage (Case 1, above), and (b) a PRA or reliability program analysis of event trees, fault trees,

failure mode and effects analyses, and common mode failure analyses, all beyond the scope of the LWA-1 proceeding. With regard to (a) the Staff admits that it does not have a basis for judging the completeness of the initiators, as evidenced by the following exchange from the ACRS meeting of June 24, 1982:

> MR. KERR: Does there now exist a description of those postulated design basis accidents?
>
> MR. STARK: They appear in the PSAR in Chapter 15, which we are reviewing to make sure they are complete. Part of our review is looking at accident initiators and we are not saying right now that that is a complete list. That is part of our review to assure it is a complete list.
>
> MR. KERR: How will you judge completeness finally?
>
> MR. STARK: Whenever we feel confident, we will describe it in the SER and defend it before you.

Transcript, June 24, 1982, Meeting of the ACRS Subcommittee on CRBR.

With respect to (b) above, Staff's position regarding some of the potential CDA initiators identified by Applicants, e.g., double-ended pipe break, is not final (1982 SSR, p. II-9). Even Applicants concede:

> It is impossible ... to confidently list all the important initiators before the event tree and fault tree analyses have been performed.

CRBRP Project, PRA Program Plan, June 18, 1982, p. 3 (emphasis added). A "preliminary list" of initiating events will be developed as part of the Applicants' PRA. A previous list was assembled in CRBRP-1.

Both CRBRP-1 and any fault tree/event tree analyses were the subject of Intervenors' Contention 1(b) and 3(a), which have been ruled beyond the scope of the LWA-1 proceeding.

With regard to the second question, it should be apparent from the preceding portions of this testimony that the mere identification of initiators and systems intended to protect against them does not preclude CDAs. Even if initiators were exhaustively identified, I have demonstrated above that all protective systems have some failure rate and determination of that failure rate is crucial to the question of whether a CDA is incredible.

In addition, one must consider the effect of human and design errors and other common mode and multiple failures. An affirmative answer to the second questions (whether identification of and protection against initiators is a sufficient condition to insure sufficiently low CDA probability) requires a showing that multiple and common mode failures cannot significantly affect the probability of a CDA. This, in turn, cannot be done without a detailed design-specific analysis.

Multiple failures, whether common mode or otherwise, should be expected as real possibilities -- one of the lessons learned from TMI-2. Consequently, it is essential, for any safety evaluation designed to determine whether a CDA can be excluded from the DBA, to treat event sequences (fault trees) as well as initiating events.

Again, these areas of analysis are part of the Applicants' Reliability Program and are outside the scope of the LWA-1 proceeding. It is instructive in this regard to review the Applicants' own description of their Reliability Program. The relationship of the Reliability Program to the overall safety and

licensing approach was described as follows:

> As stated in the PSAR, the basis for the CRBRP application is to provide a plant which meets all applicable Federal Regulations including those specified in 10 CFR 100. The application follows the conventional course for licensing of a nuclear power plant. Due to the lack of precedents for LMFBR plants, the CRBRP design approach utilizes reliability techniques extensively to provide a systematic determination of events to be included in the plant design basis.
> The overall design of the CRBRP is based on the natural three levels of design which Regulatory uses to evaluate the adequacy of proposed nuclear power plants.
>
> . . . .
>
> A systematic approach using reliability methodology is then employed to select the limiting design basis. The remaining accidents with potential to exceed 10 CFR 100 guidelines are either in the design basis envelope of the plant or excluded from it depending on the probability of the event which initiates the accident.
> The reliability program is an integral part of the overall Safety & Licensing approach and is used to assure and confirm the low probability of specific initiators not covered by precedent or Regulations and thereby allow exclusion of these initiators from the design base.

Id., p. 6 (emphasis added). These descriptions of the Reliability Program not only provide support for my testimony that CRBR design-specific testing and reliability analysis are necessary to establish the design basis for the CRBR (i.e., to exclude CDAs from the design basis) but indicate that Applicants clearly conceded as much. Now Applicants contend that they established the CRBR design basis without use of the reliability program and the adequacy of that program. This is plainly inconsistent with Applicants' earlier assertions. This issue is the subject of NRDC Contention 1(b), which has been ruled outside the scope of the LWA hearing.

Nuclear engineers all too often have tried to hide the absence of empirical evidence or confirmatory analysis by clothing their arguments in vague or meaningless generalities such as "reliance on engineering judgment." This should not be allowed. The task at hand demands more and was perhaps best stated by the Safety Analysis Group at Los Alamos National Laboratory in addressing a technical concern associated with licensing the CRBR:

> Because there is [sic] relatively large uncertainties of various origins (initial condition, data interpretation, data limitation, theoretical inadequacies) in the assessment of severe accidents and because of basic nonlinear physical tendencies, the manifestations of these imperfections in our knoweldge and capabilities become critically important. Also, the treatment of multiple uncertainties is important. Any cavalier approach justified by the hypothetical (often equated with impossible) status of these accidents can degenerate quickly to judgements (perhaps hunches or guesses) instead of facts or quantified uncertainties. The result can be a strong erosion of credibility and accident assessments that are little more than exploratory rather than definitive. A clean quantitative approach must be utilized to characterize accident tendencies given the real ranges of uncertainties. If these tendencies are divergent (large, variable ranges of energetics extending above SMBDB)[Structural Margins Beyond Design Base], difficult decisions will be required (more reliance on low initiation probabilities, design changes, etc.).[13]

I submit that no such case has been presented that justifies exclusion of the CDA from the envelope of the DBA for the CRBR.

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[13] Reactor and Structural Systems Analysis for CRBR Licensing, Final Report for Task 1, "Review of the Status of CRBR Licensing Technical Issues," and Task 2, "Develop a Plan for the Resolution of Applicable CRBR Licensing Issues," submitted to NRC Staff by Los Alamos National Laboratory, Jan. 1982, p. IV-2.

Conclusion

As a matter of science, or even simple logic, demonstration of the Applicants' case requires establishment of criteria and testing of these criteria with empirical or analytical evidence. Such an analytical test was proposed by the Applicants in 1976. The selection of the design basis events and test of Applicants' assertion that the CDA was incredible were in fact the purpose of the Applicants' Reliability Program.[14] No alternative analytical test of the Applicants' hypothesis that the CDA can be excluded from the DBA has been provided.

Nor does retreating from the level of specifics to the level of generalities enhance Applicants' and Staff's case. That is, focussing on "a reactor of the general size and type" instead of CRBR itself and asking whether it is "feasible" to make CDAs incredible rather than whether it has been done do not in this case offer Applicants and Staff a safe haven. If a finding of "feasibility" is to be based on anything more than faith and hope, it too must be anchored in past experience supplemented by analytically rigorous prediction.

David Okrent, a prominent member of the technical community and an ACRS member for many years, pinpointed precisely the gaping hole in this case:

> MR. CHECK: If we proceed down this path of minimum finding, we are going to be leaning toward the finding of feasibility.

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[14] Clinch River Breeder Reactor Project, Reliabilty Program, January 1976.

> MR. OKRENT: I think that is an inappropriate path if that is really the one you are planning to take for a variety of reasons, many of which have been said before, even at the Supreme Court.
>
> . . . .
>
> You have to have in mind, it seem to me, a reactor that resembles the one that the Applicant has in mind or it is just not ... meaningful."

Transcript, Meeting of the ACRS Subcommittee on CRBR, March 31, 1982, p. 123-124, emphasis added.

Lacking the precedent of even one substantially similar fast reactor during the licensing of which it was demonstrated that the probability of a CDA is "sufficiently low," the Applicants and Staff make a circular argument: we will require CDAs to be of low probability, hence they will be. But the physical world does not respond to such fiat. Although NRC "required" the TMI-2 core not to be severely damaged, it was severely damaged nonetheless. And although the AEC, in the same sense, "required" that no more than one subassembly melt in the FERMI-I core, at least two subassemblies defied that requirement. The list could be continued, but the point should be apparent. CDAs cannot be considered incredible for the CRBR, or for a reactor of the general size and type.

BEFORE THE
UNITED STATES NUCLEAR REGULATORY COMMISSION
ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
UNITED STATES DEPARTMENT OF ENERGY PROJECT MANAGEMENT CORPORATION TENNESSEE VALLEY AUTHORITY	)	Docket No. 50-537
(Clinch River Breeder Reactor Plant)	)	

AFFIDAVIT OF DR. THOMAS B. COCHRAN

City of Washington)
) ss:
District of Columbia)

I, Dr. Thomas B. Cochran, being duly sworn, depose and say that the foregoing testimony is true and correct to the best of my knowledge and belief.

Dr. Thomas B. Cochran

Subscribed and sworn to
before me this 16th day
of August 1982.

Barbara Pratt
Notary Public

October 1, 1981

RESUME

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April 1973-present: Natural Resources Defense Council, Inc.

Senior Staff Scientist, focusing on national energy R&D policy, principally nuclear energy issues, the breeder reactor, plutonium recycle, nuclear weapons proliferation, safeguards, and radiation exposure standards. Consultant to the U.S. Department of Energy (DOE) on nuclear nonproliferation and nuclear R&D strategy; consultant to the Comptroller General on (a) U.S. and international controls over the peaceful uses of nuclear energy, (b) Advanced Nuclear Technologies, and (c) U.S. Liquid Metal Fast Breeder Reactor Program; consultant to the Office of Technology Assessment (OTA); Member of DOE's Energy Research Advisory Board, DOE's Nonproliferation Advisory Panel, OTA's Advisory Panel on Nuclear Proliferation and Safeguards, the Nuclear Task Group of OTA's Analyses of the ERDA Plan and Program, and OTA's Gas Curtailment Study Review Panel. Consultant to Governor of Lower Saxony, West Germany, to serve as an International Expert in the Review of the Gorleben Nuclear Fuel Cycle Center. Served as a member of ERDA's LMFBR Review Steering Committee, the National Academy of Sciences' Panel on Strategy for Developing Nuclear Merchant Ships, the Task Force on Energy Conversion Research and Development of the Federal Power Survey, the United Nations' Environment Programme's International Panel of Experts on Energy and the Environment, the National Council of Churches' Energy Study Panel and the World Council of Churches Consultation on Ecumenical Concerns in Relation to Nuclear Energy. Also served as a consultant to Resources for the Future and numerous environmental organizations. Testified before Congress and federal agency hearings on numerous occasions, including testimony before the Joint Committee on Atomic Energy, the House Committee on Interior and Insular Affairs, the Joint Economic Committee, the House Committee on Small Business, and the Nuclear Regulatory Commission's Advisory Committee on Reactor Safeguards.

June 1971-April 1973: Resources for the Future, Inc.
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Senior Research Associate, Quality of the Environment Program. Studying environmental effects of the U.S. civilian nuclear power industry, residuals management in the nuclear fuel cycle, liquid metal fast breeder reactor program, national energy policy, and radiation standards. Wrote a book, The Liquid Metal Fast Breeder Reactor: An Environmental and Economic Critique.

1969-1981: Litton Mellonics Division, Scientific Support Laboratory
Fort Ord. California

Modeling and Simulation Group Supervisor. Supervised the activities of 10 operation research analysts engaged in military research pertinent to the evaluation of proposed U.S. Army concepts and material by U.S. Army CDCEC.

1967-1969: U.S. Naval Postgraduate School
Monterey, California

Lt-USNR, Active Duty; Assistant Professor of Physics; Radiation Safety Committee; part-time research involving computer studies of synchrotron radiation production in beam transport systems at Stanfard Linear Accelerator, Stanford, California.

EDUCATION

Summer 1969: University of Colorado, Boulder. Postdoctorate. Summer Institute of Theoretical Physics.

1965-1967: Vanderbilt University, Nashville, TN. Doctorate. Major: Physics. Minor: Mathematics. Research in high energy (bubble chamber) physics. NASA Fellowship. Guest Research Associate in Physics Department at Brookhaven National Laboratory, Upton, NY, studying synchrotron radiation shielding problems.

1962-1965: Vanderbilt University. MS degree in Physics. Research in radiation chemistry; AEC Health Physics Fellow; applied health physics training, Oak Ridge National Laboratory; Vanderbilt University Campus Radiation Safety Officer.

1958-1962: Vanderbilt University. BE degree in Electrical Engineering, cum laude. NROTC.

PROFESSIONAL AFFILIATIONS

American Physical Society
Maerican Nuclear Society
Health Physics Society
Sigma Xi

PERSONAL

Age: 40. Birth date: 18 November 1940. Birth place: Wash. DC. Wife: Carol J. Cochran. Two children.

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MS. FINAMORE: The second item is that, as we stated yesterday, one of our witnesses hopes to make a 2:30 plane. He informed us last night when he arrived that limousine service --

JUDGE MILLER: Well, you had better get him on the stand. You're taking his time right now.

Put him on. Let's go.

MS. FINAMORE: I'll do that in a minute.

Before I get to that, we would also like to have a few minutes for some rebuttal testimony. I was inquiring whether you'd like us to do that before or after we present these witnesses.

JUDGE MILLER: Well, that's your choice. I don't care. But I point out to you now that you do have witnesses who want to go, and all this preliminary stuff now is taking their time.

MS. FINAMORE: We'll wait until cross-examination is completed.

I would like to call --

MR. EDGAR: We reserve the right not only to cross on it, but to file testimony in response.

JUDGE MILLER: Very well. We'll --

MR. EDGAR: We'll deal with that as it occurs. But we can't predict what will happen.

MS. FINAMORE: Well, Judge Miller, you required

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that our rebuttal be oral. I would --

JUDGE MILLER: Required it? Well, no, I did not require you to file it in writing.

MS. FINAMORE: Well, if we could file it in writing, we'd prefer to do so.

JUDGE MILLER: Well, in that event, you'll have to have the witnesses on, of course. By filing it in writing, you must follow that up then.

Written testimony does not stand alone. It's prefiled.

Are we talking about the same thing?

MS. FINAMORE: I understand.

JUDGE MILLER: Okay. In other words, when you prefile something, and the next time we get together, you have the witnesses whose testimony has been prefiled.

MR. EDGAR: And, presumably, if someone wants rebuttal, they will ask leave from the Board to file rebuttal, so they can deal with it.

JUDGE MILLER: That's right.

MS. FINAMORE. I'd like to call Dr. Thomas B. Cochran, Dr. John C. Cobb and Dr. Karl Z. Morgan to the stand.

JUDGE MILLER: Come forward, please.

Dr. Cochran has been sworn and remains under oath. You other two gentlemen, if you'll raise your right

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hands and take the oath, please.

Whereupon,

THOMAS B. COCHRAN

was recalled as a witness by counsel for the Intervenors, and having been previously duly sworn by the Chairman, was examined and testified as follows:

Whereupon,

JOHN C. COBB

and

KARL Z. MORGAN

were called as witnesses by counsel for the Intervenors, and having first been duly sworn by the Chairman, were examined and testified as follows:

DIRECT EXAMINATION

BY MS. FINAMORE:

Q Dr. Cobb, would you briefly state the areas in which you intend to testify and your expertise in those areas.

BY WITNESS COBB:

A Yes. I'm testifying in regard to Intervenors' Contention 2. And as far as my competence, it relates to my research on plutonium and the Human Burden Study on contract with the EPA for the past six years.

Q And have you brought with you a copy of the EPA report indicated in your testimony?

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BY WITNESS COBB:

A. Yes, I have.

Q. And did you provide the Applicants and Staff with copies of that document?

BY WITNESS COBB:

A. Yes, I did.

Q. Do you have any changes to the testimony?

BY WITNESS COBB:

A. Yes, there are a few minor corrections.

MS. FINAMORE: Before you do so, I would like to mark for identification as Intervenors' Exhibit 8 a document entitled "Testimony of Dr. John Candler Cobb."

(The document above-referred to was marked as Intervenors' Exhibit No. 8 for identification.)

WITNESS COBB: On Page 3 the first line of the second paragraph says, "I have read the 20 September 1981 report by Stephen Chinn." That should be the 29th September. That's a typographical error.

And on Page 7, under Item 2, in the middle of the page, it says, "The bones, gonads and adrenals, which were collected from the 519 autopsies for the plutonium burden study, are still waiting in the freezers," and insert there, "at the Los Alamos National Laboratory."

It might look as if they were at the EPA, but

1-6

they're actually at the Los Alamos National Lab.

Okay. On Page 8, in the bottom paragraph, it should read as follows -- and this is simply for clarification to fit with the earlier statements I've made, but I think it makes it more clear.

"Present NRC dose guidelines for plutonium, based on the ICRP-2, which may be far too lenient by a factor of 100, allow only 8 billionths of a gram as the maximum permissible lung burden of plutonium for people in the general population."

That's the way that sentence should read.

BY MS. FINAMORE:

Q Could you repeat that again very slowly?

BY WITNESS COBB:

A Okay.

"Present NRC dose guidelines for plutonium, based on ICRP-2, which may be far too lenient by a factor of 100, allow only 8 billionths of a gram as the maximum permissible lung burden of plutonium for people in the general population."

MR. EDGAR: Could you read -- I have "Present NRC guidelines" -- "dose guidelines," was it?

WITNESS COBB: "Dose guidelines," yes.

MR. EDGAR: And then what was the "based upon"?

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WITNESS COBB: "Based on ICRP-2."

BY MS. FINAMORE:

Q. That was "NRC dose guidelines for plutonium, based on ICRP-2"?

BY WITNESS COBB:

A. Yes, that's correct. I'm just trying to make it a more clear statement.

Q. Are there any other changes?

BY WITNESS COBB:

A. On the very last page, "My concern is that we may have underestimated the toxicity of plutonium by a large factor," insert there, "perhaps 100."

"And we have probably overestimated our ability to control it, as shown by our experience with the Rocky Flats plutonium weapons facility."

Q. Are there any other changes?

BY WITNESS COBB:

A. That's all.

Q. Dr. Cochran, would you briefly state the areas you wish to testify on today and your expertise in those areas.

BY WITNESS COCHRAN:

A. Well, I wish to testify with regard to Intervenors' Contention 2 and 3c. My expertise in that area is -- aside from what was offered yesterday -- is that I

was an AEC Health Physics Fellow, a Radiation Safety Officer at Vanderbilt University, and have prepared two petitions to the Nuclear Regulatory Commission related to health effects associated with radiation exposure.

Q. Do you have any changes in your testimony, which, I believe, has been marked for identification as Intervenors' Exhibit 4?

BY WITNESS COCHRAN:

A. There is a typo on Page 4, the last sentence before the footnote, strike the words, "these hearings," for those two words appear on the next page.

Q. Do you have any other changes?

BY WITNESS COCHRAN:

A. No. There may be another typo or two, but I have no substantive changes.

Q. Dr. Morgan, will you briefly state the areas upon which you intend to testify today and your expertise in those areas.

BY WITNESS MORGAN:

A. I propose to testify in reference to Intervenors Contention 1 and 2, primarily 2.

My expertise is in the field of health physics.

Q. Do you have any changes that you wish to make in your testimony?

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MS. FINAMORE: Before you do, I would like to mark as -- for identification as Intervenors' Exhibit 9 the document entitled "Testimony of Dr. Karl Z. Morgan."

(The document above-referred to was marked as Intervenors' Exhibit No. 9 for identification.)

WITNESS MORGAN: Yes, I have several corrections and one addition.

On Page 2 of this written testimony, about two-thirds of the way from the top of the page, the left-hand side is the word "Nuremberg, Germany," it should be "Neuherberg, Germany," N-e-u-h-e-r-b-e-r-g, Germany.

Then on Page 13, a typo error at the middle of the page, the extreme right-hand of Page 13 we see 19 percent. That should have been 79 percent.

BY MS. FINAMORE:

Q. Is that on the second line of the first full paragraph?

BY WITNESS MORGAN:

A. Correct.

And then the last change, I would like to add an expository sentence at the bottom of Page 12.

Q. Where would you insert that sentence?

BY WITNESS MORGAN:

A. It could be inserted at almost any convenient

1-10

place on that page, but at the conclusion of the above discussion on this page.

Q. After the period on the final line?

BY WITNESS MORGAN:

A. That would be fine.

Q. And would you read that sentence slowly, please? Page 12 --

BY WITNESS MORGAN:

A. Page 12, it's explanatory to the discussion on that page.

"In this case, the hazard index after two four-year recycles is no longer 2.8 for Plutonium-238, but is now 34; and the index for Plutonium-241 has risen from 2.35 to 20.6. That is, if an accident in the future releases breeder fuel, the cancer risk from plutonium is 55 times greater from Plutonium-238, plus Plutonium-241, than from Plutonium-239, and 50 times greater than the NRC Staff assumed."

This is more for clarification and explanation of the above.

Q. Do you have any other changes to your testimony?

BY WITNESS MORGAN:

A. That's all of them.

MS. FINAMORE: The parties have stipulated to

1-11

the authenticity of this testimony of the witnesses.

JUDGE MILLER: What does that mean? You used that yesterday, and I didn't quite understand you. What do you mean by "they have stipulated to the authenticity of the testimony"?

Does that simply mean that it is what is represented here as their testimony, no more than that, unless you've specified?

MS. FINAMORE: And it's true and correct to the best of their knowledge.

JUDGE MILLER: They swore to that. Okay, fine.

I just wanted to be sure that there wasn't some stipulation that I wasn't discerning.

MS. FINAMORE: No.

JUDGE MILLER: Okay, you may proceed.

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MS. FINAMORE: I would like now to offer the witnesses for cross examination.

I would note, however, that in order to catch a 2:30 plane, Dr. Cobb would have to catch a limousine at 11:30 this morning if at all possible, to separate out cross-examination on Dr. Cobb it would be greatly appreciated.

It seems to me that it would be possible, since his testimony is fairly discrete, I would --

JUDGE MILLER: Well, we'll try, I'm sure, to accomodate Dr. Cobb. Counsel, all of you, have been considerate, I think, of each other and witnesses.

MR. EDGAR: Several things.

First, we, of course, reserve the right to voir dire and we intend to voir dire.

Secondly, in regard to Dr. Cobb's testimony, we are prepared to proceed with him first in an effort to accomodate his schedule. However, I would like to note one thing for the record.

On Page 1 of Dr. Cobb's testimony, which is Intervenor Exhibit 8, he references a report submitted to EPA which Ms. Finamore mentioned earlier. . That report, which I understand is more than 200 pages long, was first furnished to one of my associates at midnight last night. I,needless to say, have not had the opportunity to review

it. We, of course, object but we will proceed with cross-examination and voir dire and reserve the right to strike that testimony on that basis, that they have not provided the underlying information in any reasonably timely manner and we'll let the record speak for itself on that.

JUDGE MILLER: Very well.

MS. FINAMORE: The first time we were asked to provide that document was this week, to the best of my understanding --

MR. EDGAR: Uh-uh.

MS. FINAMORE: -- and as we stated earlier this week, we had some difficulty getting a hold of this document and were only able to get it ourselves when Dr. Cobb arrived last night and made every effort to get it to the parties as soon as possible.

JUDGE MILLER: Very well.

You may proceed with cross-examination.

MR. EDGAR: I'm going to proceed with voir dire first.

JUDGE MILLER: Very well.

VOIR DIRE EXAMINATION

BY MR. EDGAR:

Q. Dr. Cobb, first, would you clarify the area or a fair description of your area of expertise in relation to this testimony?

How would you classify your professional qualifications in relation to this testimony?

BY WITNESS COBB:

A. I am a Professor of Preventive Medicine and Community Health at the University of Colorado, as is stated here, and I've been doing this research as principal investigator on this human burden study of plutonium for the past six years and the other items, I was on the Lamm-Wirth Task Force in connection with Rocky Flats plutonium facility, and a number of other similar consulting --

Q. I want to try to pin it down.

Is your specific expertise here, relates to your testimony on the adequacy of the EPA proposed guidelines in the EPA Report, EPA 520/4-77-106,September 1977? Is that correct?

BY WITNESS COBB:

A. Let me see. Now, the --

Q. I can point you to --

BY WITNESS COBB:

A. I have a document here which relates to the EPA burden plutonium guidelines. It is dated November 30th, 1977. I don't happen to see those numbers on it but I think my expert knowledge is in the general area of the burden of plutonium in humans near a plutonium facility. Namely;

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the Rocky Flats plant. That's what I've been studying and working on, so, it would relate in general to the EPA guidelines, to the other guidelines that NRC may be involved with et cetera.

Q. Are you familiar with the basis upon which the NRC derived the dose guidelines values recommnded at Page 3-9 of their site suitability report?

BY WITNESS COBB:

A. I don't have that in front of me but I think you're referring to the NRC -- what page was this on?

Q. 3-9.

BY WITNESS COBB:

A. Roman number III-9.

And what was your question about this?

Q. Are you familiar with the basis upon which the NRC derived the dose guideline values provided at Page 3-9 on the site suitability report?

BY WITNESS COBB:

A. Well, I have not read this document.

Q. All right.

Are you familiar with the requirements of 10 CFR Part 100?

BY WITNESS COBB:

A. In a general way but not specifically.

Q. Okay.

Specifically, are you familiar with the purpose and derivation of the dose guideline values set forth in 10 CFR Part 100.11(a)?

BY WITNESS COBB:

A. I would have to refresh my memory on that.

I don't think I would want to quote it to you right now.

JUDGE MILLER: Does the witness have a copy of those regulations? I think he should have that before him.

MR. EDGAR: We can furnish him with one.

What I am asking him is really quite another question.

BY MR. EDGAR:

Q. Do you have working knowledge at the present time of the basis for and derivation of the 10 CFR Part 100.11(a) dose guidelines?

BY WITNESS COBB:

A. My understanding of the dose guidelines is that they are based on the dose of 15 rem to body tissue for an occupational exposure.

Q. All right.

And are you familiar with the purpose of those dose guidelines?

2-6

BY WITNESS COBB:

A. Yes. The purpose is to protect a worker from danger of cancer or other effects from the radiation.

Q. All right.

And are -- let me be sure I've asked the question. I don't want to cause confusion. Let me be sure I've asked it clearly.

Are you familiar with the purpose of the 10 CFR Part 100.11(a) dose guidelines?

BY WITNESS COBB:

A. I would have to say I am not fully familiar with that. I'm not an expert in this area.

Q. All right.

BY WITNESS COBB:

A. Dr. Morgan and Dr. Cochran would be witnesses on that.

Q. Fine.

Could you or do you know the logical or scientific relationship, if any, between the proposed EPA guidelines set forth in the September 1977 EPA Report and the 10 CFR Part 100.11(a) dose guidelines?

BY WITNESS COBB:

A. Well, the EPA guidelines refer to one millirad per year to pulmonary lung and that, I think, needs be clarified because the real question is, what is the

quality factor and since this is stated in rads, millirads, we need to know what the quality factor is for these alpha radiations and sometimes it's assumed that it's 10. Sometimes it's assumed that it's 20, but our research suggests to me that the quality factor may have to be as high as one thousand (1000), if, indeed, the cancers which have been observed in the area near Rocky Flats are caused by the plutonium which is found in humans in that area.

If that amount of plutonium that we found in those humans was the cause of the excess cancer, then I would have to conclude that the quality factor must be as high as about 1000 in order for that to have been the cause.

JUDGE MILLER: Pardon me. I want to be sure -- you're talking about some EPA guidelines, Dr. Cobb; is that correct?

WITNESS COBB: Yes.

JUDGE MILLER: I want to understand whether the various guidelines you're referring to, whether they are NRC, 10 CFR or EPA. Are those referring to exposure to workers, employees or the public or both?

In each case, I want to be sure we're not mixing up apples and oranges.

WITNESS COBB: That's a very good point and I think the 15 rem to the -- per year to the lung, occupational guidelines, is to be divided by 30 to get a

2-8

general public guideline and so that comes down to a half a rem or 500 millirem.

Now, that, if you assume a quality factor of a thousand, that would be a half a millirad, which puts it in the same general area as the EPA guideline of one millirad.

MR. EDGAR: May I ask a few clarifying questions? Just so we're sure that we have a frame of reference.

BY MR. EDGAR:

Q. You referred to a November 77 document that you have before you; is that right?

BY WITNESS COBB:

A. Yes.

Q. Could you read the title of that document and a description of the document, so that we have clearly in the record what it is?

JUDGE MILLER: Also the date. I think there's a little mix up there.

MR. EDGAR: Yeah.

WITNESS COBB: This is signed by Douglas M. Cossell, Administrator of the EPA and is dated November 22nd, 1977 and I guess the date on the top, November 30th, 1977, is probably the date it was published in the Federal Register.

JUDGE MILLER: In the Federal Register?

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WITNESS COBB: Yes.

BY MR. EDGAR:

Q. Could you give the Federal Register citation so that we can have that in the record?

BY WITNESS COBB:

A. That would be --

JUDGE MILLER: Volume first.

WITNESS COBB: All right.

JUDGE MILLER: Like, 45 Federal Register, Pages so and so.

WITNESS COBB: I see.

Volume 42, No. 230, Wednesday, November 30, 1977.

JUDGE MILLER: Now, pages.

WITNESS COBB: Page 60956.

BY MR. EDGAR:

Q. Is there a title on the Federal Register notice so that we can identify what it is? A caption?

BY WITNESS COBB:

A. The caption is 6560-01, [FRL 808-5] Persons Exposed to Transuranium Elements In The Environment, Federal Radiation Protection Guidance On Dose Limits.

3-1
he

MR. EDGAR: Could I ask one question of Dr. Cochran, just so that we have this defined here?

JUDGE MILLER: Yes.

BY MR. EDGAR:

Q Dr. Cochran, does that Federal Register notice refer to -- or does the Federal Register notice relate to the proposed EPA guidelines in EPA Report 520/4-77-016, September 1977?

A I would have to look at it a little further. I have not done a comparison, but let me just take a moment and I'll give you an answer.

Q And I'll ask Dr. Cobb the same question. I'm just trying to correlate them so we don't get confusion when we get into cross-examination.

JUDGE MILLER: I think Dr. Cobb has nother publication which may --

MR. EDGAR: He has the EPA report in his hand that I referred to. I'm just trying to correlate the subjects so that if the Federal Register notice is described as involving EPA guidelines that we're dealing with the same set of guidelines.

JUDGE MILLER: Okay.

WITNESS COCHRAN: The answer is yes.

WITNESS COBB: The answer is yes. On Page 21 of this larger document, on the top of the page, it refers

3-2

to one millirad per year to the pulmonary lung, which is the --

Q. I understand.

MR. TOUSLEY: Perhaps you should identify that document more completely for the record.

JUDGE MILLER: Yes. Identify it further.

WITNESS COBB: This is the proposed guidance on dose limits for persons exposed to transuranium elements in the general environment, and September 1977.

JUDGE MILLER: Yes. If not otherwise identified in the record, it should be given an identification number.

MR. EDGAR: I would like to ask you gentlemen --

JUDGE MILLER: Let me get the number on that. Who's going to put a number on it and what will it be? If it's yours, it will be 10, I suppose, NRDC.

MS. FINAMORE: That's right. I'd like to mark the report just identified for identification as Intervenors' Exhibit 9.

JUDGE MILLER: 10. 9 is Dr. Morgan's testimony.

MS. FINAMORE: Excuse me. 10.

(The document referred to was marked Intervenors' Exhibit No. 10 for identification.)

BY MR. EDGAR:

Q. I would like to ask you gentlemen if we could

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adopt some convention to refer to those EPA guidelines, another convention to refer to the 40 CFR 190 guidelines, and still another convention to refer to the Part 100 guidelines, so that we don't get confusion and overlap. It's going to be in no one's interest to have terms tossed out like guidelines, guidance, and what not, and would it be acceptable to you to refer to the document just identified as the proposed EPA environmental guidelines?

JUDGE MILLER: Well, that's a long mouthful.

MR. EDGAR: All right.

BY MR. EDGAR:

Q Or the proposed EPA guidelines would be fine with me, but I just want to hear some word that will appear in the record and nobody gets tripped up by it.

JUDGE MILLER: Well, let me ask Dr. Cobb. Is that agreeable to you to use that term consistently throughout your testimony for the purpose of that document?

WITNESS COBB: The proposed EPA guidelines sounds good.

JUDGE MILLER: All right. Now, what are the other two? Give short terms for those.

MR. EDGAR: All right. We have the 40 CFR 190 guidelines, which are referred to in Dr. Cochran's testimony, and I will use that terminology to refer to those.

JUDGE MILLER: What terminology is that

3-4

terminology?

MR. EDGAR: 40 CFR 190.

JUDGE MILLER: Okay. And the third one?

MR. EDGAR: The third one will be the NRC Part 100 dose guidelines.

JUDGE MILLER: Which you will call Part 100 dose guidelines?

MR. EDGAR: Part 100 dose guidelines.

JUDGE MILLER: Very well. We have them all identified now, some in short form.

WITNESS COCHRAN: I would like --

JUDGE MILLER: Do you have a caveat?

WITNESS COCHRAN: Yes, sir. I would like to ensure that the 40 CFR 100 is not referred to as guidance but as standards.

MS. FINAMORE: Did you mean to refer to 40 CFR 190?

WITNESS COCHRAN: Yes. Excuse me. 40 CFR 190.

MR. EDGAR: We will call them 40 CFR 190 standards.

JUDGE MILLER: Very well.

MR. EDGAR: That's acceptable.

JUDGE MILLER: Very well.

MR. EDGAR: Then there is a final category that could come up in the conversation at some point today, and

3-5

to be sure that we don't get that one confused, there is in the Federal Register 40 Fed Reg 7836, January 23rd, 1981, proposed federal radiation protection guidance for occupational exposures, proposed recommendations, requests for written comments and public hearings. That's an EPA notice.

I would like to refer to those as the proposed occupational exposure standards, or the proposed occupational standards. Would that be acceptable?

JUDGE MILLER: Is that a greeable to the expert witnesses, Dr. Cobb, Dr. Cochran?

WITNESS COCHRAN: It might be helpful to put the EPA proposed --

MR. EDGAR: Good idea, yeah. We'll call them proposed EPA occupational standards.

JUDGE MILLER: Okay.

MR. EDGAR: And then the final category would be NRC --

WITNESS COCHRAN: Excuse me. Guidance, proposed EPA occupational --

MR. EDGAR: Guidance?

WITNESS COCHRAN: -- exposure guidance.

MR. EDGAR: Well, could I leave out exposure? Would you accept --

WITNESS COCHRAN: I will accept that.

MR. EDGAR: -- proposed EPA occupational

guidance, or the EPA occupational guidance?

WITNESS COCHRAN: That's quite acceptable.

MR. EDGAR: All right. And the final category would be NRC Part 20 standards, which are NRC's existing radiation protection standards. Will that be clear if I use the term Part 20?

WITNESS COCHRAN: To me, yes.

MR. EDGAR: To the entire group of experts?

WITNESS COCHRAN: Yes.

JUDGE MILLER: They're nodding their heads yes, or otherwise not dissenting. Consider it established.

MR. EDGAR: All right.

BY MR. EDGAR:

Q Dr. Cobb, do you know the logical relationship, if any, between the proposed EPA guidelines and the NRC Part 100 guidelines?

BY WITNESS COBB:

A I don't consider myself an authority in this area.

Q All right. And is it then true that you do not know what the logical relationship is between the proposed EPA guidelines and the NRC Staff's recommended Part 100.1(a) guidelines set forth at Page 3-9 of the site suitability report?

/ / /

3-7

BY WITNESS COBB:

A. Yeah, I think that would be correct.

Q. All right. Before you prepared your testimony did you read NRDC Contentions 2(e) and 11(d)?

BY WITNESS COBB:

A. No.

Q. Have you now read NRDC Contentions 2(e) and 11(d) prior to the time that I've asked this question?

BY WITNESS COBB:

A. I don't believe I have.

Q. All right. Do you know whether your testimony relates to any matter in issue in these proceedings?

BY WITNESS COBB:

A. Yes, I think it relates to Contention 2 and, as a matter of fact, I'm now remembering the 11(d) that was referred to in Dr. Cochran's testimony, and I did go over that last night. Yes, that's on Page 2 of Dr. Cochran's testimony. And I did read that. Guideline values for permissible organ doses used by Applicants and Staff have not been shown to have a valid base.

Q. All right. Do you hold yourself out as having expertise concerning the 10 CFR Part 100 dose guideline values?

BY WITNESS COBB:

A. Not in any particular way, no. I think

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Dr. Morgan and Dr. Cochran are the people you should talk to about that.

Q. Do you hold yourself out as having any expertise concerning the dose guideline values recommended by the NRC Staff in the site suitability report at Page 3-9?

BY WITNESS COBB:

A. Now, this is this document, right?

Q. Yes.

BY WITNESS COBB:

A. What I would like to say is that my expertise is in the area of the amount of plutonium in humans in the area near Rocky Flats resulting from spills of plutonium coming from Rocky Flats, and in the area of cancer incidence in that same population. That's what I would like to testify on, and I don't want to get into all these regulations. They're so confusing.

Q. That's why I was asking you the question. If you answer my question directly, then we don't need to go into those things.

So is it true that you do not hold yourself out as an expert concerning the dose guideline values recommended by the NRC Staff in the site suitability report at Page 3-9?

BY WITNESS COBB:

A. Yeah, I would say that's correct.

Q. All right. Is it true that you do not hold

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yourself out as an expert concerning ICRP-26?

BY WITNESS COBB:

A. That's correct.

Q. Is it true that you do not hold yourself out as an expert concerning ICRP-30?

BY WITNESS COBB:

A. That's correct.

Q. Is it true that you do not hold yourself out as an expert concerning the hot particle hypothesis of Drs. Cochran and Tamplin?

BY WITNESS COBB:

A. I'm certainly not an expert, but I am familiar with it.

Q. All right. Is it true that you do not hold yourself out as an expert concerning the plutonium bone dose phyothesis of Dr. K. Z. Morgan?

BY WITNESS COBB:

A. Again, I'm familiar with it, but I'm not an expert.

Q. All right. At Page 8 of your testimony --

MR. EDGAR: Mr. Chairma.., we've concluded the voir dire of Dr. Cobb. We will reserve our motion to strike the -- I would like to proceed with the merits of Dr. Cobb's testimony, subject to the motion to strike on voir dire and the motion related to the documents that were not furnished

3-10

in a timely manner.

JUDGE MILLER: Very well.

MR. EDGAR: However, if I can go through the merits of his testimony at this time, I think I can free him to get on the plane.

JUDGE MILLER: Very well.

MR. EDGAR: Or at least -- the Staff may have questions, but I'll do the best I can to get through quickly.

JUDGE MILLER: All right. I think that's reasonable. Your reservation will be noted for the record, and we would like to accommodate the witness.

Proceed.

CROSS-EXAMINATION

BY MR. EDGAR:

Q Dr. Cobb, I'd like to get one clarification on Page 8. The last paragraph which appears in the text on Page 8, as you have made some clarifying changes this morning, and I wanted to get a definition of, or a further clarification, if I could.

As I understand it -- well, let me ask the question directly.

As modified, the sentence now reads, in the first clause, the present NRC dose guidelines for plutonium based on the ICRP, am I correct?

/ / /

3-1'

BY WITNESS COBB:

A. ICRP-2.

Q. Okay. I'm sorry. Okay. So that's a correct statement.

What NRC dose guidelines are you referring to in that phrase?

BY WITNESS COBB:

A. I'm referring to the -- particularly in regard to the lung, which is of particular concern to me, the 15 rem per year guideline for an occupational exposure, divided then by 30 for the general population.

Q. Okay. Now, you refer to a 15 rem occupational standard in the NRC dose guidelines. Is that -- do you know whether that's the NRC Part 20 dose guidelines?

BY WITNESS COBB:

A. I'm not sure.

Q. All right. Do you know which NRC guidelines, by regulation or more specific indentification?

BY WITNESS COBB:

A. Well, I think you have other experts here on these guidelines. That's not my field of expertise.

Q. Well, all I want to do is clarify it so we know what -- Dr. Cochran, or Dr. Morgan, could you help in --

BY WITNESS COCHRAN:

A. I think I could help. Dr. Cobb's expertise is

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in the area related to the quality factor which is used in all of the guidelines --

Q No, the question is not --

BY WITNESS COCHRAN:

A -- and his expertise does not --

Q Let me ask you the specific question --

THE REPORTER: I cannot get but one of you at a time.

MR. EDGAR: Yes. I want to -- I don't --

WITNESS COCHRAN: I was talking first, Mr. Edgar.

JUDGE MILLER: Hold it, Dr. Cochran. I think he believes you're not going into what he's trying to ascertain regarding Dr. Cobb, so me get it clearly first.

Now, what is it you wish to get for the record?

MR. EDGAR: The first phrase, as now modified, on Page 8 of Dr. Cobb's testimony, in the last paragraph, refers to present NRC dose guidelines for plutonium based upon the ICRP-2. All right.

BY MR. EDGAR:

Q What I want to know is, what specific set of regulations, standards or guidelines we're talking about for the purpose of identification. Is it -- which of the five things we discussed morning is it? That's all. It's quite that simple.

JUDGE MILLER: All right. I think the record

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shows that Dr. Cobb said it's a certain value but he doesn't know what number or what guidelines. Now, it's a very limited matter, if Dr. Cochran, you or anyone else can help.

Can you tell us which of the five documents he's referring to, or which contains that?

WITNESS COCHRAN: I'm sorry. I didn't understand your question there, Judge Miller.

JUDGE MILLER: All right.

Dr. Cobb, let's go back, what is it that you mean by the material which you amended in your testimony that counsel just read to you? What were you referring to?

WITNESS COBB: I was referring to the ICRP-2, which uses a 15 rem to the lung per year for occupational exposure.

JUDGE LINENBERGER: Sir, sorry, but you used the term NRC guideline in your modification to that sentence, and we need to know what NRC guideline refers to, what document.

JUDGE MILLER: Just the document.

JUDGE LINENBERGER: What document, not doses.

WITNESS COBB: I'll have to ask Dr. Cochran that.

WITNESS COCHRAN: The problem that's occurring is due to the fact that Dr. Cobb is not familiar with the

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specific --

JUDGE MILLER: So he said.

WITNESS COCHRAN: -- NRC regulation --

MR. EDGAR: Exactly.

WITNESS COCHRAN: -- either 10 CFR 100 or --

MR. EDGAR: And that's all we're trying to ask.

WITNESS COCHRAN: -- Part 20, but his testimony goes to --

JUDGE MILLER: We know that.

WITNESS COCHRAN: -- the quality factor.

JUDGE MILLER: We just want to know what's the number that he would be referring to if he knew what it was.

WITNESS COCHRAN: It would be all of the above, 10 CFR 100, the guideline values for plutonium --

JUDGE MILLER: It's impossible.

WITNESS COCHRAN: -- for plutonium --

JUDGE MILLER: Dr. Cochran, it's not possible. Now, let us explain what we want for the record. We're not --

MR. EDGAR: Well, let me --

JUDGE MILLER: -- trying to get into the merits of anything right now.

MR. EDGAR: Let me ask Dr. Morgan a question.

BY MR. EDGAR:

Q Dr. Morgan, where are NRC occupational standards for plutonium contained, in what section of the regulations?

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BY WITNESS MORGAN:

A. They're contained in Title 10, Part 20.

Q. And are those based on ICRP-2?

BY WITNESS MORGAN:

A. Yes.

MR. EDGAR: That's all we wanted to get.

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WITNESS COCHRAN: I'm sorry, Judge Miller, did you understand my point, that the quality factors in those are the same as the quality factors that we are discussing today.

JUDGE MILLER: I understand. We just weren't into it that deeply. We were just simply trying to get the initial identification. Your answer may well be coming up and I suspect it will.

Thank you, Doctor.

BY MR. EDGAR:

Q. Would you please turn to Page 1 of your testimony, Dr. Cobb?

BY WITNESS COBB:

A. All right.

Q. And if I could refer you to the second paragraph on the page --

BY WITNESS COBB:

A. Yes.

Q. -- the second sentence, the language reads and I quote:

"I am concerned that present and proposed standards or guidelines for plutonium --",

and just stop there.

What present and proposed standards or guidelines

for plutonium are you making reference to in that sentence?

BY WITNESS COBB:

A. I making reference to, first of all, the EPA document that we have identified, the November, 1977, and also the NRC guidelines that we've just been talking about.

Q. The NRC guidelines referred to on Page 8 of your testimony?

BY WITNESS COBB:

A. That's correct.

Q. Okay. Fine.

Do you agree that the data available do not prove that the proposed EPA guidelines are inadequate?

BY WITNESS COBB:

A. Yes. I made it quite clear that it is no proven. It is a concern that comes from my understanding that there is an excess of cancer in this area and that the amount of plutonium in individuals in that area is exceedingly small, so that one would have to conclude that if this excess of cancer is caused by that amount of plutonium, that the guidelines have been inadequate.

Q. All right.

Do you know what the status of these guidelines is?

BY WITNESS COBB:

A. The EPA guidelines?

Q. Yes.

BY WITNESS COBB:

A. I understand that they have not been promulgated as yet.

Q. Fine.

You make reference on Page 3 of your testimony -- and let me be more specific.

In the first full paragraph on Page 3 in the next to the last line, you make reference to a set of Colorado State Guidelines.

BY WITNESS COBB:

A. Right.

Q. Are the Colorado State Guidelines now in effect?

BY WITNESS COBB:

A. It's my understanding that they are and that there is some question about this in legal circles.

What I'm referring to is the soil, two disintegrations per minute per gram of soil, which is a Colorado State Health Department Guideline for the amount of plutonium that should not be exceeded in the soil in order to grant permission for construction of housing in the area, and that is considerably stricter by a factor of about 25, than the proposed EPA Guidelines.

Q. All right.

BY WITNESS COBB:

A. And my understanding is that the Colorado State Guideline is now in effect because Colorado is a cooperating State and, therefore, has the right to make such guidelines, as long as they are stricter than the corresponding Federal Guidelines.

Q. I take it that this is a soil contamination standard or guideline --

BY WITNESS COBB:

A. That's correct.

Q. -- which would require utilization of special techniques if one were to construct upon property contaminated at those guideline values?

BY WITNESS COBB:

A. Yeah.

Q. All right.

Now, the EPA Guidelines that we've discussed, could you describe the purpose of those guidelines?

BY WITNESS COBB:

A. As I understand it, the purpose is to protect the general public from cancer and other hazards of radiation.

Q. Do you have the EPA report before you that you previously identified?

BY WITNESS COBB:

A. This document?

Q. Yes. That is marked for identification as --

JUDGE MILLER: Intervenors' Exhibit 10.

BY MR. EDGAR:

Q. -- Intervenors' Exhibit 10.

I have portions of that document copies, I can hand out, if anybody would like to see it .

MR. EDGAR: So, I would like to do that now.

JUDGE MILLER: Very well.

MR. EDGAR: I have just handed portions of that document to others who did not have it, for their reference, so they could follow the questioning. I do not intend to mark -- the document has already been marked for identification.

BY MR. EDGAR:

Q. What I'd like to do, Dr. Cobb, is try to get a little more precise definition of the manner in which these guidelines would be implemented and if I might refer you to Page 21 of Intervenors' Exhibit 10 --

BY WITNESS COBB:

A. I have that.

Q. And am I correct that these guidelines would constitute a set of control measures for areas which have presently existing contamination or for newly contaminated

areas?

BY WITNESS COBB:

A. I would suppose but I'm not privy to what was in their minds, but I would suppose it would be both.

Q. I'm just asking for your understanding. I mean, I assume you've worked with this set of guidelines to some extent; have you?

BY WITNESS COBB:

A. Well, this was given to me by Paul Smith of the EPA in Denver and he had flagged the relevant areas to our study so that I am familiar with it in connection with our study but not -- I don't claim to be privy to what was in the mind of the EPA when they developed this.

Q. Okay.

Is it fair to say that you have an understanding of the purpose of these guidelines?

BY WITNESS COBB:

A. Yes, I think so.

Q. All right.

And is it true that the recommendations are to be used only for guidance on possible remedial actions for the protection of the public in instances of presently existing contamination or of possible future, unplanned releases of transuranic elements?

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BY WITNESS COBB:

A. Well, since these guidelines have not been promulgated and the whole thing is in a state of total confusion, as far as I'm concerned, I think it's pointless to speculate as to how they will eventually be used. How they are intended to be used.

I mean there are lots of different people in the EPA now than there were a year ago and I don't know what's going to happen.

Q. All right.

BY WITNESS COBB:

A. I don't think anybody does.

Q. All right.

Is it true that for newly contaminated areas, under these guidelines, control measures should be taken to minimize both residual levels and radiation exposures of the general public?

BY WITNESS COBB:

A. I think so.

Could you repeat that again?

Q. All right.

Is it true that for newly contaminated areas, under these guidelines, control measures should be taken to minimize both residual levels and radiation exposures of the general public?

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BY WITNESS COBB:

A. I would suppose so but, again, I don't claim to be an expert on --

JUDGE MILLER: Counsel, if you're referring to any particular section there, I think it would only be fair to direct the witness' attention to it.

MR. EDGAR: All right. I'll be glad to do that.

BY MR. EDGAR:

Q. I'm looking at Page 21 of the document in question and that contains statements about the guidelines. At the top of the page --

BY WITNESS COBB:

A. At Page 3 there it says:

"The recommendations are to be used only for guidance on possible remedial actions for the protection of the public health in instances of presently existing contamination or of possible future unplanned release of transuranium elements."

Q. Yeah.

BY WITNESS COBB:

A. "They are not to be used by Federal Agencies as limits for

planned releases of transuranium elements into the general environment."

Q. Okay.

And I guess I should ask you, is that a fair statement of your understanding of the purpose of the guidelines?

BY WITNESS COBB:

A. Well, it's what it says in this document.

Q. I'm asking for your understanding, that's all.

BY WITNESS COBB:

A. How the EPA is going to use this or whether it will ever promulgate it or what their minds are, I have no idea.

Q. All right.

WITNESS COCHRAN: Excuse me, Judge Miller. Just for clarification, I -- my views are not completely in conjunction --

JUDGE MILLER: I understand.

BY MR. EDGAR:

Q. I said -- the question was "your understanding".

JUDGE MILLER: It's limited to the understanding of Dr. Cobb, because we know that you're examining him, primarily, individually at the present time. It does not bind the other members one way or the other.

BY MR. EDGAR:

Q And Dr. Cobb is free to express his understanding.

Dr. Cobb, may I refer you to the paragraph enumerated 3 on Page 21, right above the one that you read, and does paragraph 2, as you read it, represent a fair characterization of your understanding of the purpose of the guidelines?

BY WITNESS COBB:

A It says:

"For newly contaminated areas, control measures should be taken to minimize both residual levels and radiation exposures of the general public. The control measures are expected to result in levels well below those specified in Paragraph 1. Compliance with the guidance recommendations should be achieved within a reasonable period of time."

That seems like a reasonable approach, to me.

Q All right.

Could you tell me whether in the last sentence that you just read, that the terms compliance with the

guidelines recommendations should be achieved within a reasonable period of time, refers to the reasonable period of time following new contamination of an area?

BY WITNESS COBB:

A. I don't know what was in their minds.

Q. All right.

Would you please turn to Page 2 of your testimony and I'd like to call your attention to four enumerated paragraphs on Page 2 and my question will relate to the 4th enumerated paragraph, which I guess these are four enumerated sentences and the area I'd like to ask you about is the fourth item that reads, and I quote:

"The findings of animal experiments showing that plutonium and other alpha-emitters cause mutations and genetic defects, as well as cancers."

Do you have any particular experiments in mind there?

BY WITNESS COBB:

A. Well, for one, I can remember the experiments done by Dr. Douglas Grunn at the Argon National Laboratory. Injecting plutonium into rats. I believe it was rats and observing the genetic effects on offspring.

Q. Do you recall what levels of exposure in these studies resulted in genetic effects?

BY WITNESS COBB:

A. Not offhand.

Q. Do you know the order of magnitude?

BY WITNESS COBB:

A. I think he was using a rather large dose.

Q. Microcurie quantities?

BY WITNESS COBB:

A. I would expect so. I think it was several orders of magnitude larger than one would expect to find in an environmental situation.

Q. All right.

And in reference to that point, if I could refer you to Page 4 of your testimony and particularly Paragraphs B.and C. in the same vein , what I'd like to find out is, in your Rocky Flats studies what levels of exposure, in terms of order of magnitude, were involved?

BY WITNESS COBB:

A. Well, as is stated in Paragraph B., the average for our study in the lungs was two-tenths of a picocurie per person.

Q. All right.

And in the other organs noted on the page, we're also talking about picocurie quantities?

BY WITNESS COBB:

A. That's correct.

Q. Now, the next question is not meant to do anything but clarify the record.

What is the relationship numerically between a microcurie and a picocurie?

I'm not trying to be condescending. I'm just trying to get it in the record.

BY WITNESS COBB:

A. All right.

A microcurie would be 10 to the minus 6 curies and a picocurie would be 10 to the minus 12.

Q. So there is a factor of a million difference; is that correct?

BY WITNESS COBB:

A. That's correct.

Q. And a picocurie is one one millionth of a microcurie?

BY WITNESS COBB:

A. That's correct.

Q. On Page 5 of your testimony -- I just want to understand.

As I understand your testimony, you have a concern that more studies ought to be done in relation to the Rocky Flats area; is that correct?

BY WITNESS COBB:

A. Yes, it is.

Q And you are not stating or expressing the opinion that exposure to plutonium from Rocky Flats was, indeed, the cause of ten percent excess of cancers in the population of that area?

BY WITNESS COBB:

A No. I'm simply saying that, if this excess of cancers were caused by plutonium, then we would have to assign a very much higher quality factor to the alpha radiation than has hitherto been done, under these conditions.

Q All right.

MR. EDGAR: We have no further questions of Dr. Cobb, and insofar as we're concerned, we will reserve the motion to strike and try to complete all of the cross of Dr. Cobb.

JUDGE MILLER: All right.

Then you're through with both the voir dire examination of Dr. Cobb's qualifications for the purpose of expression of expert opinion?

MR. EDGAR: That's correct.

JUDGE MILLER: As well as the merits thereof, subject to whatever motions are deemed appropriate?

MR. EDGAR: That is correct.

JUDGE MILLER: Staff?

MR. JONES: The Staff has no cross of this

witness.

JUDGE MILLER: Any redirect?

MS. FINAMORE: Yes, there is.

May we take a small recess?

JUDGE MILLER: All right. Ten minutes?

MS. FINAMORE: That's plenty.

(Short recess.)

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JUDGE MILLER: Would you be seated, please.

Ready to engage in redirect, I guess.

MS. FINAMORE: Yes.

JUDGE MILLER: You may proceed.

REDIRECT EXAMINATION

BY MS. FINAMORE:

Q. Dr. Cobb, you mentioned earlier that your testimony involves quality factors.

Would you explain what a quality factor is?

BY WITNESS COBB:

A. Yes. A quality factor is used to compare different kinds of radiation. An alpha radiation, which is what comes from plutonium, which we are concerned about, has a quality factor which is very uncertain but has been estimated to be somewhere between and ten and one thousand, and this is the factor by which you would multiply the dose in rads to get the dose in rems. That is the effective dose.

Q. Are these quality factors involved in any way in developing federal guidelines for radiation protection?

BY WITNESS COBB:

A. Yes. They have to be used in any proper guidelines.

Q. Can you explain how they would be used?

BY WITNESS COBB:

A. Well, if you are trying to establish a safe level

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of radiation and you've established it, for example, for gamma radiation, then you want to estimate what the effect of a certain amount of alpha radiation would be, you would multiply the amount of rads of alpha radiation by this quality factor in order to come up with a figure in rems to give the effective dose for the tissue in question.

Q Are you aware of whether or not quality factors are used in setting any NRC guidance or standards for radiation protection?

MR. EDGAR: I'll object to a leading question.

JUDGE MILLER: It's a little leading, but we'll allow it for the moment.

Go ahead.

WITNESS COBB: Well, obviously any -- every regulation that deals with alpha radiation has to use a quality factor, and it's my understanding that the 10 CFR 100, the NRC regulation, does use a quality factor of ten.

BY MS. FINAMORE:

Q Do you consider that quality factor to be adequate?

BY WITNESS COBB:

A As I say, there's a very large degree of uncertainty. It may be a hundred times that. It may be as high as a thousand. And this is what I have concluded from the research that we have been doing.

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Q. Can you explain why you believe there's a large degree of uncertainty in that quality factor?

MR. EDGAR: Objection.

JUDGE MILLER: Sustained. You're getting beyond redirect now. The objection is sustained.

BY MS. FINAMORE:

Q. Can you quanify that degree of uncertainty?

MR. EDGAR: Objection. The testimony speaks for itself.

JUDGE MILLER: Sustained.

MS. FINAMORE: I have no further questions.

JUDGE MILLER: Is there anything further now from any counsel?

MR. EDGAR: I have one question to follow up on recross.

RECROSS-EXAMINATION

BY MR. EDGAR:

Q. Dr. Cobb, you indicated that you believed that the -- or it was -- let me strike that, and not characterize your testimony.

Was the basis for your understanding that Part 100 uses a quality factor of ten?

BY WITNESS COBB:

A. Just my memory.

Q. All right. And that's based on your familiarity

5-4

with 10 CFR Part 100?

BY WITNESS COBB:

A. Yes, what my memory is of that and what people have told me about that.

Q. All right.

BY WITNESS COBB:

A. I don't claim to be an expert on it, but I have friends who are.

MR. EDGAR: All right. Thank you.

JUDGE MILLER: Staff?

MR. JONES: We have no questions.

JUDGE MILLER: I didn't understand you. Did you say you had questions?

MR. JONES: We have no questions.

JUDGE MILLER: Oh. Thank you.

Judge Linenberger.

BOARD EXAMINATION

BY JUDGE LINENBERGER:

Q. Just one question, Dr. Cobb. There is a term that's frequently used and designated as RBE, or relative biological effectiveness. Does this have any direct relationship with the term you have used, designated as quality factor?

BY WITNESS COBB:

A. It's my understanding that the RBE is an earlier

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term, and that nowadays people use quality factor to mean essentially the same thing, but with slight modifications.

JUDGE LINENBERGER: Thank you, sir. That's all I have.

JUDGE MILLER: Thank you. I believe that's all, then, and Dr. Cobb may be excused if that be the wish of counsel and the witness.

Thank you. Have a pleasant trip home.

All right. We'll now proceed with the cross-examination of the balance of the panel. I think the record indicates that so far Dr. Cobb was interrogated upon his own areas, both of substance and of expertise. In at least one instance there was indication that the other panel members might hold different views, whatever the situation. I think we should be clear in the balance now of the examination whether this be to individuals and whether they're testifying essentially as individuals or whether, as in some other panels, their testimony will be used or blended or merged, so clarify whatever it is. We don't know. We just --

MR. EDGAR: I'll try to be as explicit as I can in addressing my questions where they relate to an individual or to collective opinion or, you know, a joint and several opinion.

JUDGE MILLER: Okay. Proceed.

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MR. EDGAR: I'd like to conduct voir dire examination on Dr. Morgan, if I may.

JUDGE MILLER: You may.

VOIR DIRE EXAMINATION

BY MR. EDGAR:

Q. Dr. Morgan, have you performed a review of any of the four Clinch River Breeder Reactor Plant general design features which are important to prevention of a core disruptive accident?

BY WITNESS MORGAN:

A. No.

Q. Do you hold yourself out as having any direct expertise in regard to those general design features for CRBRP?

BY WITNESS MORGAN:

A. No.

Q. Do you hold yourself out as having any expertise in the area of nuclear reactor engineering?

BY WITNESS MORGAN:

A. Expertise is a term that has to be defined in terms of quality. I certainly have more knowledge than an average farmer. I might even have more knowledge about it than you, sir. I probably have some knowledge, but I don't consider myself an expert or to be a nuclear engineer.

Q. All right. You probably do have more knowledge

5-7

than I do. I will concede that.

JUDGE MILLER: But you have friends.

(Laughter.)

MR. EDGAR: I must say I have friends, too.

JUDGE MILLER: Fortunately, I do too.

(Laughter.)

MR. EDGAR: I thought I was going to get to go on to my next question without incurring further damage.

JUDGE MILLER: You're relatively untouched so far.

(Laughter.)

BY MR. EDGAR:

Q. Dr. Morgan, have you performed any technical review of any analyses of core disruptive accidents for the CRBRP?

BY WITNESS MORGAN:

A. Not specifically.

Q. All right. If you have not specifically, what was the nature of your review? There's some implication there.

BY WITNESS MORGAN:

A. I intended it, sir. I have read over, in the past, numerous reports in reference to the Clinch River Breeder Reactor. Earlier I was concerned about the positive void coefficient that could develop under certain conditions.

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I raised objection at the time and I was pleased that they began to lean toward a heterogeneous design rather than homogeeneous and dstributed the U-238, and I've been concerned about some other engineering features, but I do not consider myself a nuclear engineer.

Q. All right. When was the last time that you reviewed any analyses of CDA's for CRBRP?

BY WITNESS MORGAN:

A. This morning.

Q. All right. Okay. Do you hold yourself out as having any expertise in the area of nuclear reactor containment design?

BY WITNESS MORGAN:

A. Not expertise in terms of my previous definition, though again I would be glad to see whether certain general members of the public or I know more about it. I think I know more about that, from extensive reading, than the average member, but I'm not an expert, but I'm not completely ignorant, either, if that's what you mean in that sentence.

Q. All right. Are you familiar with the characteristics of the CRBRP containment design?

BY WITNESS MORGAN:

A. Not with any of the details; in a general way.

Q. Are you familiar with the general characteristics?

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BY WITNESS MORGAN:

A. Yes, I have, in the past, read over the reports giving information on the general characteristics.

Q. Could you describe those general characteristics?

JUDGE MILLER: Of what, now?

MR. EDGAR: Of the CRBRP containment design.

JUDGE MILLER: Containment design. Very well.

WITNESS MORGAN: I said I'm not an expert in that and I can only describe it in terms of a layman and what I have read in the newspapers.

BY MR. EDGAR:

Q. All right.

BY WITNESS MORGAN:

A. For the double containment, et cetera, not too different from the light water reactors in that respect.

Q. All right. You earlier mentioned that you had reviewed a CDA analysis this morning. What CDA analysis did you review this morning?

BY WITNESS MORGAN:

A. I reviewed the ones referred to in my written testimony.

Q. And could you point to your written testimony so that we can identify the specific analyses referred to in your testimony?

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BY WITNESS MORGAN:

A. That is Docket No. 50-537.

Q. I'm sorry, your testimony is marked for identification as Intervenors' Exhibit 9. My question is, you said that you reviewed some CDA analyses this morning. I asked you what analyses, and you said the ones in your testimony.

Could you show me the specific analyses in your testimony to which you referred when you made that statement?

BY WITNESS MORGAN:

A. This might take about an hour to discuss, if you want me to do that.

JUDGE MILLER: No, he's asking you simply to identify. You read something this morning and he wants now to have the citation of --

MR. EDGAR: All I want to know is which one. It's that simple. I don't need to know anything about it if it's in the testimony.

JUDGE MILLER: Just the identification is all that's asked for at present, Dr. Morgan.

(Long pause.

WITNESS MORGAN: I've referred to it on Page 6 in this testimony. Page 7 in the testimony. Page 9 in the testimony. Page 11 in the testimony. Page 12 in the

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testimony. In the record, Page 13. Page 15. Page 18. Page 19. Page 21. I believe those are most of the specific references, though I had indirect references throughout perhaps most every page.

BY MR. EDGAR:

Q. On Page 8 of your -- well, let me ask preliminarily, are you the sole author of your testimony?

BY WITNESS MORGAN:

A. I got help in preparing it. At the present time I'm working on some -- I'm doing conculting work on some 50 different cases, so I spent only a very limited time in preparing it.

Q. Who helped you?

BY WITNESS MORGAN:

A. I made most of the calculations, and certainly checked everything thoroughly.

Q. Who --

BY WITNESS MORGAN:

A. Dr. Cochran assisted me in collecting some of the information and getting the references.

Q. Did he assist you in writing the testimony?

BY WITNESS MORGAN:

A. Yes.

Q. Would you turn to Page 8 of your testimony, and in the first paragraph which begins the text at the

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top of the page, the first full sentence on Page 8, which begins with "In particular" and ends with "transuranium elements," did you write that sentence?

(Long pause.)

BY WITNESS MORGAN:

A. I got assistance in preparing this sentence.

Q. And who assisted you?

BY WITNESS MORGAN:

A. Dr. Cochran.

Q. Did he write the sentence?

BY WITNESS MORGAN:

A. Not verbatim, no.

Q. Did he write the first draft of the sentence?

BY WITNESS MORGAN:

A. Yes.

Q. And then you edited it?

BY WITNESS MORGAN:

A. Right.

Q. Do you believe it to be true?

BY WITNESS MORGAN:

A. I do.

Q. On Page 14 of your testimony, in the second full paragraph, first sentence, which begings with the language "More precise estimates" and ends with the language "CRBR fuel" and also a citation there to Board

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rulings, did you write that sentence?

BY WITNESS MORGAN:

A. I only edited the sentence prepared for me by Dr. Cochran.

Q. Do you believe that the sentence is true?

BY WITNESS MORGAN:

A. I do.

Q. Have you read the Board's rulings?

BY WITNESS MORGAN:

A. Yes.

Q. And you fully understand the Board's rulings?

BY WITNESS MORGAN:

A. I don't think anyone fully understands them.

(Laughter.)

Q. You have read both Board Orders cited there? Is that true?

BY WITNESS MORGAN:

A. I have, yes.

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BY MR. EDGAR:

Q Do you stand personally behind everything in this testimony?

BY WITNESS MORGAN:

A I do.

Q Is it a fair characterization that Dr. Cochran drafted the largest portion of the testimony?

BY WITNESS MORGAN:

A I would give him credit for that, yes.

MR. EDGAR: We have no further voir dire. We'll reserve our motions to strike. We're ready to proceed with questioning --

JUDGE MILLER: Very well. You may cross-examine on the merits then.

CROSS-EXAMINATION

BY MR. EDGAR:

Q Dr. Morgan, I'd like to ask a few questions about your personal opinions in regard to the text on Page 5 of the testimony, and if I might point you to the second full sentence from the bottom which begins with the language, "Considering the accidents that have occurred," and ends with the language, "is not credible."

Take your time. I just want an index to that.

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6-2

BY WITNESS MORGAN:

A. This is on Page 5?

Q. Yes. Page 5 under the caption Roman one. And to give you some better -- it's about -- a little better than halfway down the page, and the sentence starts with "Considering the accidents that have occurred already" --

BY WITNESS MORGAN:

A. I thought you said the second from the bottom. That's why I --

Q. It was the second full one from the bottom. I guess it is the third full sentence. I stand corrected.

Are you familiar with the sequence of events that occurred at EBR-I that you have mentioned in this sentence of your testimony?

BY WITNESS MORGAN:

A. I don't claim to be an expert in this, sir. But, again, I don't claim to be ignorant of the subject. I read tens of thousands of documents per year. I might refer you and the Honorable Judges to ORNL/NSIC-176, Page 101, which gives a description of this accident.

Q. All right. And are you familiar with that description of the accident?

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6-3

BY WITNESS MORGAN:

A. Yes, I have read over this. I wouldn't say that, again, I'm an expert in reactor accidents. But I have looked over this -- the entire text, not just this one breeder reactor accident.

Q. But you don't consider yourself to be an expert in reactor accidents; is that what you just told me? I just want to be sure I understand that.

BY WITNESS MORGAN:

A. Yes. But I don't want to say yes and no, because "expert" connotates too much. Beginning during the 29 years I was Director of the Health Physics Program at Oak Ridge, I had interface with numerous engineers. Dr. Eppler, in particular.

I read -- perhaps not all -- but most of his publications and attended his seminars, had private discussions with him.

I have the highest regard for his integrity and his ability to ferret out these accidents. Since going to Atlanta, becoming a Professor at Georgia Tech, again, I have interface with nuclear engineers more than farmers and dentists and others.

So I'm not trying to say -- I'm not completely unaware of the problem or ignorant of the problem, as the word "expert" or "non-expert" my connotate.

6-4

I do have some information based on reading of many hundreds of documents and discussions with numerous experts in the field.

Q Are you familiar with the events at the Enrico Fermi Atomic Plant, Fermi-I, described in that sentence of your testimony?

BY WITNESS MORGAN:

A Yes, on the same basis. I can go through that, if you choose.

I'm associated with a group that's looking into the Three Mile Island accident, for example. And because of that, I have some current interest in problems that lead to reactor accidents, perhaps more so than I would have were I expending all my time in other areas of interest, such as radium exposure, medical exposure, return of the natives to the Marshall Islands. I'm working on all these other cases and many more.

But because of my current association with the TMI-II accident and what led to the accident, I am interested in all types of reactor accidents, not just breeders or converters, but also with -- especially right now -- with light water reactors, both BWR and PWR, as well as Kennedys and other types.

Q Would you describe your involvement in -- please identify your involvement in regard to TMI-II.

6-5

BY WITNESS MORGAN:

A. I'm working with the law firm, David Berger, in attempting to assist that firm in the proper disposition of the monies made available through the $25 million litigation awarded under the Price-Anderson Act.

Q. All right. Are you familiar in detail with the sequence of events at TMI?

BY WITNESS MORGAN:

A. Yes.

Q. And do you consider yourself to have expertise in regard to the behavior of that reactor from an engineering standpoint during that accident?

BY WITNESS MORGAN:

A. No. I'm not an engineer, so I can never claim expertise as an engineer.

Q. May I refer you to Page 10 of your testimony. There is described on Page 10 a table and some text discussing the so-called puff release analysis.

I just want to identify it first. Are you familiar with all of the assumptions which the NRC Staff made in regard to the puff release analysis?

BY WITNESS MORGAN:

A. No one is, sir; and I don't believe the Staff is itself familiar with all its assumptions. I know in a general way they assumed exponential decay, and then at

6-6

the end of the period they assumed suddenly all of the remaining radionuclides available for release.

Q. Instantaneously?

BY WITNESS MORGAN:

A. Yes.

Q. Do you know what assumptions they made concerning plate-out and fallout of aerosols within the containment during the entire course of the 0 to 30 day period in the analysis?

BY WITNESS MORGAN:

A. No, I did not need that information in my evaluation. I only used the release amount.

Q. But the answer is: You're not familiar with what assumptions they made out on plate-out and fallout?

BY WITNESS MORGAN:

A. I did not discuss that in my testimony, so I'm not ... Excuse me. You said plate-out in the containment?

Q. Yes. Plate-out and fallout in the containment.

BY WITNESS MORGAN:

A. It's a little odd term, to say "fallout in the containment." But I'll accept that.

Q. All right.

Do you know whether the NRC Staff's assumptions regarding plate-out and fallout had any significant

6-7

effect on the values calculated?

BY WITNESS MORGAN:

A. Would you define where you mean fallout of -- Do you mean inside --

Q. Inside the containment, yes.

BY WITNESS MORGAN:

A. I don't know what their specific assumptions are. They don't give the details in the reports I read. I'm referring now in the containment.

Q. Right.

And so, therefore, it is a fair conclusion that you cannot express an opinion as to the effect of that assumption in the calculation?

BY WITNESS MORGAN:

A. I have not expressed an opinion on it. And unless I were an engineer, like Dr. Eppler working in the field, determining the various plate-out characteristics in the presence of sodium vapor and perhaps some water in the fire and all these conditions, I don't think unless I were an expert in this field, that I could cast judgment on what fraction of the various fission products would necessarily plate out under these extreme and untried and unknown conditions.

Q. And if I might refer you to -- Oh, just -- There was a term used that I wanted to get clarified.

6-8

When you discussed the assumptions of which you were aware, you used the term that there was exponential decay. Could you explain just for clarity of the record what physical process you were referring to in the context of that calculation?

BY WITNESS MORGAN:

A Could you be specific and refer to the page or where --

Q No, it was --

JUDGE MILLER: Your oral testimony, a little bit ago --

BY MR. EDGAR:

Q Let me just go back and see if I can clarify. Any characterization that I make of your testimony in this clarification, you don't have to accept.

But what I asked was: Were you familiar with the assumptions that the Staff made in the analysis?

You responded that you weren't familiar with them all, but you -- there was an assumption of exponential decay.

And what I wanted to find out was what did you have in mind when you used that phrase. That was all.

BY WITNESS MORGAN:

A Okay. By exponential decay we mean, usually, if it's a time exponential, it's E to the minus lambda t.

6-9

In other words, lambda is the decay constant; and t is time.

If it's shielding or something like that, we usually see E to the minus muX t, in which mu is centimeters to the minus one, and X is centimeters. There has to be dimensions.

Or putting it in graphical terms, if you plot an exponential on semilog paper, you should get a straight line. It's that type of drop-off, when you plot your results on semilog paper.

Q. Now when you used exponential decay, you were referring to the behavior of the source term for the radiological dose calculation, were you not?

I'm just trying to straighten out physically when you made the statement what part of the calculation you were referring to.

Was it on the radioactive source term, or was it on some other parameter, such as pressure?

BY WITNESS MORGAN:

A. I would like you to identify in my testimony where that was.

Q. It was not in your written testimony, Dr. Morgan. I'm not suggesting that. I'm saying you said this orally, in response to a question.

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6-10

BY WITNESS MORGAN:

A. Could the court reporter read back what I said?

JUDGE MILLER: I'm afraid that would be impossible, Dr. Morgan. With the equipment we use --

WITNESS MORGAN: Well, I hate to accept what he said I said without knowing specifically --

JUDGE MILLER: Well, all right.

What do you remember? If you don't remember what you said, just say so. I don't care. We're just trying to get the record straight with the definition of the terms that I believe you did use in your oral statement a while ago.

If you don't remember, that's all right. If you do, tell us what you meant.

What is the term you're referring to now?

MR. EDGAR: Exponential decay.

WITNESS MORGAN: If you plot your results on semilog paper, it will follow more or less a straight line.

JUDGE MILLER: Well, that's what it is. But I guess what the Board wants to know: What difference does it make? In other words, what is the significance in terms of what you were talking about?

WITNESS MORGAN: It means that, first of all,

6-11

for radioisotopes, the drop-off is always exponential.

For mixed fission products, it varies more or less as t to the minus 1.2 power. Since this is a logarithmic or power term, this would be a straight line on log/log paper.

And it was in this general context that I was thinking.

So it depends on the specific part of the discussion, whether I would move from a log/log to a semilog.

MR. EDGAR: Fine.

JUDGE MILLER: Thank you. That's sufficient. Thanks, Dr. Morgan.

Okay. You may proceed.

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BY MR. EDGAR:

Q Are you familiar, Dr. Morgan, with the current state of technology in regard to the plate-out and fallout of aerosols of plutonium in a sodium environment?

BY WITNESS MORGAN:

A No.

Q If I might refer you to Page 20 of your testimony, there is at the top of the page in enumerated paragraph one, in the first sentence in that paragraph, you mention the mechanism of resuspension. Could you define what you mean by the resuspension mechanism, as you've used it here?

BY WITNESS MORGAN:

A This is why I wanted better interpretation earlier on plate-out, and you called it fallout, in the containment.

Q Right.

BY WITNESS MORGAN:

A Here we're not in the containment; we're in the environment. And by resuspension, I have in mind the radionuclide, be it a transuranic or fission products or what not, settles to the ground and may go through some cycling and then is resuspended, primarily by wind currents.

Q Okay. In the available modeling -- Excuse me.

7-2

In regard to the state of the art in today's technology from modeling exposure pathways, what is the time frame of interest for the resuspension pathway? Is it weeks, months or years?

BY WITNESS MORGAN:

A. For plutonium it should be many years. For short-lived radionuclides, like Sodium-24, I would normally be willing to take, say, six half-lives, down to one percent.

Q. Let me refer you, Dr. Morgan, to Page 21 of your testimony in the first full paragraph appearing on the page. You, in the second sentence, make reference to a September 1977 EPA summary report.

Is that reference the same as Intervenors' Exhibit 10?

BY WITNESS MORGAN:

A. I believe so, yes.

Q. You cite in regard to that report Pages 20 and 21. Does that report anywhere explicitly state a purpose of applying these values as reference values for reactor siting?

BY WITNESS MORGAN:

A. I don't recall. I'd have to read each page, at least glance read it, to be sure.

Q. Okay. But at the present time without

7-3

reviewing the document, you could not say?

BY WITNESS MORGAN:

A. No, I could not. By implication it would, in my opinion. I could not say whether it's site --

Q. That would be -- Pardon me.

That would be your interpretation that it would; is that correct?

BY WITNESS MORGAN:

A. Yes, unless they qualify a sentence and speak of radiation exposure to the public, I would assume it applies to the general case and would include nuclear power plants; and they, in turn, would include light water, as well as the heavy water and the breeders, as well as the burners.

Q. Do you know whether there is any explicit statement in the report that indicates an intention to apply those guidelines for the purpose of determining reactor site suitability?

MS. FINAMORE: Objection. That has been asked and answered already.

JUDGE MILLER: You may answer it.

WITNESS MORGAN: Yes?

JUDGE MILLER: You may answer it.

WITNESS MORGAN: I'm not sure how I can answer that honestly without getting into the political arena.

7-4

I think it was knowing members of EPA and members of NRC -- I'm on four or five committees of NRC, and I know many of their people there, and I have former students working in both EPA and NRC, so I have personal contacts.

But if I may say, Your Honor, I feel that it was intended to have strong implication for nuclear power plants, but for political reasons it probably was not specifically stated on any of the pages.

As I say, I'd have to glance read each page to be sure whether it was at any point specifically stated. But I know that EPA would like -- or these certain members of EPA would like to have had this applied to the nuclear power plants, but probably because of political boundary restraints, it wasn't stated specifically.

JUDGE MILLER: It was not, did you say, Mr. Morgan?

WITNESS MORGAN: It was not stated specifically, probably.

JUDGE MILLER: Thank you.

BY MR. EDGAR:

Q Do you have any information to show that EPA at any time intended to apply this guideline for the purpose of site suitability evaluation under 10 CFR Part 100?

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7-5

BY WITNESS MORGAN:

A. I know that certain employees of EPA had hoped that it would, that there were discussions between the two government agencies relating to where the responsibilities and aegis began and ended.

But because of political restraints, nothing to my knowledge was put in writing to indicate that. My answer to the question would be yes.

Q. Are you familiar with the current status of those EPA guidelines?

BY WITNESS MORGAN:

A. No. I would have to get on the phone to check with some of my associates to see what it is today. They change on a -- more or less on a daily basis, as far as I can tell.

Q. Have they ever been promulgated as requirements by EPA?

BY WITNESS MORGAN:

A. Under the past administration, I think they were considered more or less as requirements. Under the present administration, I don't believe any of the documents and regulations espoused by EPA can really be considered as requirements, when the environmental pollution is involved.

Q. Is it your understanding that the EPA

7-6

guidelines are, in fact, proposed guidelines --

BY WITNESS MORGAN:

A. Did you say -- Excuse me?

Q. Is it your understanding that the EPA guidelines are, in fact, proposed guidelines, and not final requirements?

BY WITNESS MORGAN:

A. That's my understanding.

Q. Would you please turn to Page 24 of your testimony. I'd like to refer you to the first sentence -- Excuse me.

I'd like to refer you to the first paragraph appearing on the page, the first full sentence in the text.

Would it be a fair characterization of this sentence as to what it means, that you are uneasy with the Staff's turning away from ICRP-2 to ICRP-26 as the basis for deriving the site suitability dose guidelines?

BY WITNESS MORGAN:

A. I would have to qualify your question, if I may, sir, to answer properly.

As I read the statements of the Staff of what they did, they used ICRP-2 in certain parts of their calculations and ICRP-30 and 26 in other parts. So it's

somewhat difficult to answer your question in one sentence.

Q. All right.

BY WITNESS MORGAN:

A. But I feel that -- and I can go into great detail if you choose -- that they made a great mistake in several places in their calculations, in their numbers, in the use of ICRP-2 and ICRP-26 and 30.

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7-8

Q What I'm trying to understand is: Your sentence talks about the rather cavalier attitude of the Staff in turning away from the radium standard on which the ICRP-2 and NRC plutonium and transplutonic permissible exposure levels are based.

What I'm trying to understand is your statement about the Staff's turning away from the radium standard on which ICRP-2 and NRC plutonium exposure levels are based.

Does that mean that you would prefer to see reliance on ICRP-2, as opposed to ICRP-26 and 30?

WITNESS MORGAN: May I speak to the Judge?

JUDGE MILLER: Can you answer that, Dr. Morgan?

WITNESS MORGAN: Not with a yes or no, because it's yes for this part and no for the other.

JUDGE MILLER: Okay. You may --

WITNESS MORGAN: If I could have two minutes, or three, I could explain this, I think, so that it would be understandable.

JUDGE MILLER: Yes, you may.

WITNESS MORGAN: But I can't do it in a yes or no.

JUDGE MILLER: All right. You may have -- Keep it as terse as you can, but I understand that it will not be a simple yes or no. So you may give an

7-9

explanation.

WITNESS MORGAN: Thank you very much.

For a quarter of a century, I was on the main commission of ICRP. I was chairman of the Internal Dose, which prepared Handbook 2, which we're talking about. So I do have some knowledge about how these things developed, the shortcomings, the strengths and the weaknesses of these two reports to which you referred.

And on this I feel the Staff and others who evaluated this site were cavalier in their choice of reference points.

While I was a member of ICRP -- and I'm still an emeritus member -- some years ago, I committed the unforgiveable sin of reaching 65, so I'm not employed here anymore, and I'm doing consulting work.

But I do keep up with these documents and I read them.

But while a member of ICRP and while these changes were coming about, we had numerous discussions in the main commission because there was a great inconsistency in these levels.

The basic numbers for rates -- dose rates to critical organs (as we called them) -- and we allowed five rems per year to the total body, to the red bone marrow and to the gonads.

7-10

But that seemed to be very inconsistent. We all saw that right off, Your Honor.

Why would you allow the same dose, five rems to my total body and to my gonads and red marrow. Certainly, it would be worse to have five rems to the total body.

Well, we debated this over and over for years. So, finally, we decided we had to make some change. That led to ICRP-26 and ICRP-30.

The late Dr. Walter Snyder, who helped prepare -- and he with the assistance of Mary Rose Ford -- they prepared the data, made the calculations for ICRP-30 here at the ORNL Laboratory.

Well, it developed then that Dr. Snyder and I, and others on the commission, thought the solution was simple: Just lower the total body dose, say, to 2 1/2 rems, but keep the other values constant.

What did they do? Well, they jumped from the frying pan into the fire.

They solved this inconsistency, but they ran into even greater -- much greater difficulties because now the doses to the -- They set up what they called weighting factors for ICRP-26 that you asked about.

And if you get the inverses of these weighting factors and multiply them by five rems to the total

body, then you get -- they would now be increasing the doses allowed to the body organs at a time when the BEIR Report, UNSCEAR Reports, ICR Reports -- the ICRP Reports and all the reports of the Staff show that the cancer risk is greater than we thought it to be back in 1959 when Handbook 2 was written, but yet it means that now they would be increasing the allowed dose.

I met with NRC Commissioners on at least one occasion, specifically on this; and more recently, with the ACRS committee dealing with this.

And I'm pleased to the present moment. The Nuclear Regulatory Commission has not been so gullible as to feel that it has to swallow everything that ICRP says.

So they have not, to my knowledge, adopted the Handbook 26 and Handbook 30.

Well, what's wrong with Handbook 30 and 26? Using the weighting factors --

MR. EDGAR: I don't want to interrupt your train of thought, but can I ask a simple question for a layman here.

BY MR. EDGAR:

Q Do I understand correctly, Dr. Morgan, that in your professional opinion you do not agree with the ICRP-26 and 30?

7-12

I'm trying to get an explicit statement. Is it your professional opinion that you do not agree with ICRP-26 and 30?

BY WITNESS MORGAN:

A. I'll agree with -- If could go just two more minutes, I could answer.

Q. Yes.

BY WITNESS MORGAN:

A. My answer is yes and no. I have to explain.

JUDGE MILLER: Go ahead.

WITNESS MORGAN: So they jumped out into the fire. Now they increased the dose to the bone from 30 rems per year -- and using their formulation, with the weighting factors it would go up to 107.

And they said, "Oh, my gosh, we can't do that, because this would mean that people would be dying of irradiation syndrome. We don't want our workers to get doses like that."

So what did they do, after they jumped out of the frying pan into the fire?

They reached up into the air and picked out the number 50 rems and set this 50 rems as an upper limit. It has no scientific bearing, no biological basis whatever.

And so now they have jumped the dose to the

skeleton from 30 rems to 50 rems, and then increased some of the others by factors of three and four at a time when we know that the radiation risk is greater.

So that's one objection I have to ICRP-26 and 30.

Now, I have some points in favor of it. Another reason that we had trouble in the main commission with Handbook 2 was that it used specifically the critical body organ. And there's a lot of merit in that.

The critical body organ -- it would take a long time to give its full definition. Put in simplistic terms, it is that organ having the greatest concentration of the radionuclide. There are exceptions. I won't take the time to ...

But the trouble with that is in the calculation here -- for example, with plutonium, the permissible body burden for plutonium is point oh -- excuse me, if I go too fast, would you hold up your ...

The permissible body burden for Plutonium-239 and Plutonium-240 is .04 microcuries. And that .04 microcuries is based solely on the dose to the skeleton, averaging the dose over the entire skeleton, in terms of the plutonium -- only the Plutonium-239 that's in the skeleton.

And the same way with values to the liver. You

know, for long exposure the liver, rather than the bone, becomes the critical tissue.

Take the liver, for example, and let's take some other isotope to make it more general. If it's cobalt in the liver -- and I believe the liver is the critical organ for cobalt -- it certainly would lead to trouble if you take the liver, and only the cobalt in the liver to determine the permissible body burden, because cobalt has two gammas and very high energy, a little more than one NDV --

JUDGE MILLER: Slow down just a little, please, for the reporter.

WITNESS MORGAN: The cobalt gives off two gammas, 100 percent each. And so if you limit your calculation of permissible body burden of cobalt to what cobalt is contained in the liver, then you can be in error at least by a factor of two -- in some cases, for some other radionuclides, more than two, because the liver gets exposed from cobalt that's contained in the muscle, the GI tract, the bone and other organs.

So that's a plus for Handbook 26 and Handbook 30. It considers the dose, not just from what's contained in the critical organ, but the dose received by the critical organ from -- in some cases, small amounts in other organs.

7-15

Now I won't go into further discussion. But I think the main reason -- in specific answer to your question -- that I object to any group that is so gullible as to accept all of the conditions of ICRP-26 and 30 -- and at the time we know the cancer risk is greater than it was 25 to 30 years ago -- to now be raising all of the allowable doses for members of the public and occupational workers by factors of two or three or more.

JUDGE MILLER: All right. Please continue.

BY MR. EDGAR:

Q You made reference to a specific 50 rem per year limit in the course of your discussion just now. Is that the so-called non-stochastic limit of ICRP-26?

BY WITNESS MORGAN:

A. Yes. The stochastic limit would be about 170, about 167, which is based primarily on carcinogenesis -- cancer induction, whereas this is based on the radiation syndrome, essentially -- has that characteristic -- dropping over dead or showing symptoms of nausea or vomiting and other things that would be non-stochastic.

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Q And I take it you don't agree with that value, or the implementation of it.

BY WITNESS MORGAN:

A. I don't agree with changing numbers that are based on radium, and the radium value of a tenth microcurie or microgram of radium 226, just one-tenth micocurie -- microcuries and micrograms are the same here -- this corresponds to 30 rems per year average over the skeleton. It's based on a half a decade of human experience of the carcinogenesis of persons dying of cancer, bone sarcomas and carcinomas as a consequence of this burden of radium in their skeleton, and that corresponds, as I say, to 30 rems per year.

Now, what is ICRP-26 and 30 doing? It's raising the level 30 rems per year, corresponding to ten micrograms of radium 226, to 50 rems per year, almost a doubling, allowing twice as many cancers, if you believe in the BEIR report, as we would allow before for occupational work or members of the public.

I do not believe that's a good move.

Q Isn't it true that -- I just want to get some orientation -- in this sentence on Page 24 of your testimony you refer to the 0.1 microcuries of radium 226 reference on which ICRP-2 and NRC plutonium and transplutonic permissible exposure levels are based, in that context,

8-2

when you refer to the NRC permissible exposure levels, am I correct that you're referring to Part 20?

BY WITNESS MORGAN:

A. You said NRC.

Q. Yeah. Loo in the last two lines. There's a reference made to NRC plutonium and transplutonic permissible exposure levels.

BY WITNESS MORGAN:

A. Yes.

Q. Do you mean there a reference to the 10 CFR Part 20 limits or values?

BY WITNESS MORGAN:

A. Title 10, Part 20. Title 10, Part 20, Tables 1 and 2.

Q. All right. Okay.

Dr. Cochran, could I refer you to Page 25 of your testimony, and in particular, the first full paragraph on Page 25, and it would be the third sentence. You make reference to an FFTF site suitability analysis did consider these pressure and thermal loading effects and included the possible effects of venting, and you cite to the NRC safety evaluation report.

BY WITNESS COCHRAN:

A. Yes.

Q. Are you certain that the analysis referred to

8-3

on those inclusive pages was a site suitability analysis, as the term is used in the context of Part 100?

BY WITNESS COCHRAN:

A. Mr. Edgar, as you may be aware, the fast flux test facility was not licensed by the Nuclear Regulatory Commission and therefore 10 CFR 100 was not formally applied.

However, there were efforts to calculate the radiological consequences of -- for purposes of assessing the radiological consequences associated with accidents at that facility, and the methodology employed was in terms of, the types of calculations are analogous to the methodology that would be employed had that reactor been through the licensing at the NRC -- undergone licensing by the NRC.

I would also point out that this, of course, is a -- would be more -- this particular safety evaluation report would be comparable to an analysis one would perform at an OL stage rather than a CP stage, and in that sense the analysis is not judged -- is not for the purpose of judging whether you should build the plant, but more -- be more correctly characterized as judging whether you did it right.

Q. Do you have the report with you?

BY WITNESS COCHRAN:

A. Yes, I do.

Q. Could you point to me on the pages you cite

8-4

the specific indication of what type of analysis was employed, the analytical methods?

BY WITNESS COCHRAN:

A. Well, like many Nuclear Regulatory Commission reports, they don't properly document their assumptions, and so a simple reading of the report will not provide that --

JUDGE MILLER: Well, what's your question?

WITNESS COCHRAN: -- degree of information. Some of the assumptions are given --

MR. EDGAR: Just a moment, please, Dr. Cochran.

WITNESS COCHRAN: -- in section --

JUDGE MILLER: Hold it just a moment.

MR. EDGAR: The Board has a question.

JUDGE MILLER: No, I asked what was your question.

BY MR. EDGAR:

Q. My question is, what analytical methods were employed in the report? That was the first question.

MR. EDGAR: They're described in Dr. Cochran's testimony as site suitability analyses, and as the Board knows, there are different methods of analyses applied to CDA's in the mechanistic sense, and then in the site suitability analysis, and he said they were site suitability analysis, and he's got a cite here to the FFTF SER and so I

8-5

wanted to find out where in the SSR, or the SER for FFTF it says that this is a site suitability analysis and that the methods are as Dr. Cochran says analogous. I'm trying to get indexed. I'm getting a speech.

JUDGE MILLER: Well, let's get a specific answer, please.

WITNESS COCHRAN: To the extent that the methodology is fully described -- .I mean to the extent that it's described, it's described in Section 15.3.7, beginning at Page 15-58 and ending with the end of that chapter. This particular discussion refers to the use of guideline -- dose guidelines such as 10 CFR Part 100, specifically 10 CFR Part 100. It also refers to particular codes that were used to perform the calculation and gives some, but not a full explanation of the assumptions that were used in that --

Q. What codes are identified?

BY WITNESS COCHRAN:

A. They're identified on Page 15-59, CACECO, HAARM-3, PACT-4, ORIGEN.

Q. Is that all?

BY WITNESS COCHRAN:

A. Yes.

Q. Those are the only codes that are referenced in that section of the safety evaluation report?

8-6

BY WITNESS COCHRAN:

A. Well, with the caveat that I have not re-read the section completely, that's the codes that stand out.

Q. But that's -- it is your understanding, without having to go back and review the document again, that those inclusive pages of the Report 15-58 through 15-65 are indeed confined to site suitability analysis and these codes that you have listed?

BY WITNESS COCHRAN:

A. I don't want to -- I would not draw the inference that it was a site suitability analysis appropriate for judging the suitability of a reactor that's licensed under 10 CFR Part 100. In 10 CFR Part 100 there were, for example, statements made in the text that -- that we have made calculations somewhat realistic, although still on the conservative side of these assumptions that I spelled out, I would draw the inference from that that those assumptions were less conservative than would be appropriate for a --

JUDGE MILLER: Mr. Edgar, we're taking an awful --

WITNESS COCHRAN: -- 10 CFR 100 analysis --

JUDGE MILLER: Pardon me. Hold it.

Dr. Cochran, I've told you, please to stop.

WITNESS COCHRAN: I beg your pardon.

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JUDGE MILLER: All right.

We're taking an awful lot of time, it seems to the Board, in lengthy, nonresponsive answers.

MR. EDGAR: I agree.

JUDGE MILLER: Your function as cross-examiner is to --

MR. EDGAR: I understand.

JUDGE MILLER: -- precisely identify, it is also to disclaim nonresponsive answers to be stricken. Now, let's get everybody on the track.

MR. EDGAR: All right.

Well, all I'm trying to do is establish a foundation question and I'm getting speeches, and I move to strike the last answer, it's clear.

MS. FINAMORE: Objection. I think it is responsive.

JUDGE MILLER: Responsive to what? What do you deem the question to be to which that lengthy answer was responsive?

MS. FINAMORE: Well, the question was, is it relevant to a site suitability analysis. Dr. Cochran was explaining he did not believe it was relevant to a site suitability analysis under --

JUDGE MILLER: Then why didn't he just say so?

MS. FINAMORE: -- 10 CFR Part 100, but that it

8-8

was relevant -- because the facility was not licensed but that it was relevant --

JUDGE MILLER: Then why did we have another five minutes after that point? Why couldn't that have been the answer given?

MS. FINAMORE: Because it was a "yes but" answer.

JUDGE MILLER: Well, I'm going to strike that answer. Now, ask your question. If he hasn't had an opportunity to answer it fairly, ask it with some precision and let's get some short responsive answers, so we're going to start invoking the rules that prevail in court, now, if you're a cross-examiner. Okay.

BY MR. EDGAR:

Q In the second paragraph on that page, the second sentence, you have two terms used, annulus filtration and bypass leakage.

What do you mean by the term, as you use it here, bypass leakage?

BY WITNESS COCHRAN:

A Excuse me. I have --

Q Page 25, second paragraph, second sentence.

JUDGE MILLER: Hold it. Do you find it?

WITNESS COCHRAN: Yes. I found it.

/ / /

8-9

BY MR. EDGAR:

Q What do you mean by the term bypass leakage?

BY WITNESS COCHRAN:

A. I'm referring to the assumptions --

Q. Explain to me physically what you mean by bypass leakage? You said it in your testimony. Explain it.

BY WITNESS COCHRAN:

A. All right.

(Long pause.)

MR. EDGAR: Mr. Chairman -- Judge Miller, I'm going to object to the time the witness is taking. He has to know what that means.

WITNESS COCHRAN: I did my --

JUDGE MILLER: Go ahead.

WITNESS COCHRAN: I apologize. My -- the reason I hesitated is --

JUDGE MILLER: No. Never mind the reason. Just what did you mean by the term?

WITNESS COCHRAN: Bypass leakage, to me, means leakage from the reactor vessel in such a way -- well, excuse me, not the reactor vessel, leakage from the reactor containment in such a way that the annulus filtration of that particular gas and radioactivity -- active -- activity mixture would not be filtered.

/ / /

8-10

BY MR. EDGAR:

Q. And so it's direct from primary containment to the atmosphere, is that it?

BY WITNESS COCHRAN:

A. Not necessarily.

Q. How else would it be?

BY WITNESS COCHRAN:

A. Well, it could be through other buildings in the -- associated with the reactor plant, but that's not important in terms of the assumptions that are made in the site --

Q. It's not an important distinction, is it?

BY WITNESS COCHRAN:

A. No. No.

Q. All right. You could have answered the question about --

JUDGE MILLER: Now, let's not -- next question.

BY MR. EDGAR:

Q. You're bypassing the secondary containment, is that correct?

BY WITNESS COCHRAN:

A. You're leaking out of the secondary containment without filtering in the annulus.

Q. When you refer to bypass leakage -- strike that. Now, are you familiar with the annulus

8-11

filtration system, the design concept for CRBR?

BY WITNESS COCHRAN:

A. Not in great detail, no.

Q. Are you familiar with the conceptual elements of the design?

BY WITNESS COCHRAN:

A. To some degree.

Q. Do you think you have a working knowledge of that system?

BY WITNESS COCHRAN:

A. The -- well, in the NRC site suitability source term analysis they're not referring to any particular annulus filtration system, in terms of design specifics and therefore the question seems somewhat irrelevant.

MR. EDGAR: I move to strike the answer.

JUDGE MILLER: The answer is stricken.

Next question.

WITNESS COCHRAN: What was the --

BY MR. EDGAR:

Q. The question is: Are you familiar with the basic design concept of the annulus filtration system?

BY WITNESS COCHRAN:

A. In a general sense, yes.

Q. All right. Can you describe how it works?

/ / /

8-12

BY WITNESS COCHRAN:

A. Well, not in any detail. There is an annulus between the containment -- steel containment and the reinforced concrete confinement, which is approximately five feet in width and the -- that area is held under negative pressure and there is a pumping and filtering system such that the -- any leakage into that annulus is pumped through filters for removal of radioactive -- the radioactivity, and some of the air that's exhausted from the filters is -- the major part is forced back into the inner containment and the balance is released to the environment.

Q. All right. Are you familiar with the design concept for the vent from containment for beyond design basis accidents?

BY WITNESS COCHRAN:

A. What do you mean by beyond design basis accidents?

Q. For the --

BY WITNESS COCHRAN:

A. That's your term. Not mine.

Q. All right. We'll define it.

JUDGE MILLER: All right. Rephrase the question to contain the definition the witness was asking for.

MR. EDGAR: Sure.

BY MR. EDGAR:

Q. Are you familiar with the Applicants'Third Level -- excuse me -- thermal margin beyond the design basis, design concepts?

BY WITNESS COCHRAN:

A. In some respects.

Q. Are you familiar with the general features provided for thermal margin beyond the design basis?

BY WITNESS COCHRAN:

A. Some of those general features.

Q. Are you familiar with how the containment vents for those features?

BY WITNESS COCHRAN:

A. How the containment vents?

Q. Is there a containment vent within the population of those third level--

BY WITNESS COCHRAN:

A. Yes.

Q. All right.

Is that the same vent as the ventilation system that we just discussed?

BY WITNESS COCHRAN:

A. No.

Q. And how does that vent work? What is the ventilation path?

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BY WITNESS COCHRAN:

A. It's a filtered vent directly from the secondary to the environment.

Q. Directly from the secondary to the environment?

BY WITNESS COCHRAN:

A. To the best of my knowledge. To the best of my knowledge, that's correct.

Q. You're not certain, though; are you?

BY WITNESS COCHRAN:

A. I -- no, I'm not.

Q. Referring you to your testimony on Page 25, second paragraph, second sentence, you first state, and I quote:

> "The Staff source term analysis, unlike that of FFTF, assumes that radiological releases to the environment, even from the most severe accident, will only occur via annulus filtration and bypass leakage of .001 percent per day."

Then I further quote the next sentence:

> "Yet the Applicants have proposed a system whereby, in the case of a CDA, all radioactivity in the containment will be released directly

9-3

to the environment through filter vents."

Is it true that --

BY WITNESS COCHRAN:

A. That's a misstatement. That's not a correct statement.

Q. What is not a correct statement?

JUDGE MILLER: Will should be would? Is that what you refer to?

WITNESS COCHRAN: All should be stricken.

JUDGE MILLER: Just a minute. You're changing the testimony now?

WITNESS COCHRAN: No. Wait. Excuse me. That is an incorrect statement with the word "all" in. I would --

MR. EDGAR: You would strike "all"?

JUDGE MILLER: You wish to strike the word "all"?

WITNESS COCHRAN: I wish to strike "all" because it does not imply the annulus filtration system --

JUDGE MILLER: All right.

The word "all" will be stricken. The testimony is amended in that regard.

Now, you've had the rest of it read to you. Do you recall the question you were asked, based on --

MR. EDGAR: He has not been asked a question, yet.

BY MR. EDGAR:

Q. Do the Applicants' site suitability source term analyses assume any release through the filtered vents mentioned in the second sentence?

BY WITNESS COCHRAN:

A. Not in their site suitability source term analysis. Only in their treatment of margins,as what the Applicants described as margins, beyond the design basis.

Q. That's right.

So, no one has purported to use those filtered vents in connection with suite suitability analysis; is that correct?

BY WITNESS COCHRAN:

A. No, and that's my problem with the --

Q. Well, answer my question.

BY WITNESS COCHRAN:

A. I did answer it.

Q. Did the Applicants purport to use those filtered vents from containment in site suitability analysis?

JUDGE MILLER: For which --

MS. FINAMORE: Objection.

JUDGE MILLER: Just a moment.

The witness answered no. Everything after the word "no" will be stricken.

You've got the no answer.

Next.

MS. FINAMORE: Judge Miller, can you explain why the witness is not permitted to qualify his answer?

JUDGE MILLER: Because everything is getting so qualified that the tail is starting to wag the dog very significantly. You're taking time unnecessarily beyond any fair representation.

We've asked the witness to respond directly. To explain only when necessary and we will rule whether it appears necessary.

There's been too much questioning. We have also asked the examiner to shorten and sharpen his questions.

Those are the reasons.

Proceed.

WITNESS COCHRAN: How about a no, but?

JUDGE MILLER: Well, the no probably can. The but, we'll take a look at.

Proceed.

BY MR. EDGAR:

Q Page 29, Dr. Cochran, first paragraph appearing on the page.

BY WITNESS COCHRAN:

A. I have it in front of me.

Q. What is the underlying basis for the EPA non-stochastic limit of 30 rems per year? The EPA recommended 30 rems per year non-stochastic limit.

BY WITNESS COCHRAN:

A. I think Dr. Morgan may be able to give you a more precise answer, but it's my understanding that it's based on the argument that Dr. Morgan alluded to earlier, that it would be inappropriate to increase the existing organ limit -- the then existing organ limitations under ICRP-2 of 30 rems, up to 50 and so they simply lowered the non-stochastic limit to 30 rems.

Q. What was the scientific basis for 30 rems? If you know.

BY WITNESS COCHRAN:

A. I think the scientific basis was to protect the human health.

Q. Are you familiar with the basis of EPA's recommended 30 rem non-stochastic limit?

BY WITNESS COCHRAN:

A. Well, my familiarity only extends to discussions with members of the Staff and I don't have firsthand knowledge of the private inner counsel that they may have had on this matter, but it's my understanding that the

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intent was as I previously described. The objective which I previously described.

Q. And that's as fully as you can explain it?

JUDGE MILLER: I think we will sustain objection to that. You're pressing beyond, now, the fact.

Next.

WITNESS COCHRAN: Excuse me. I might add, if I had a chance to refresh my memory --

JUDGE MILLER: Hold it, Doctor. Hold it. Whatever you care to add will be picked up on redirect and we will determine whether or not it's necessary.

Proceed with your next question.

BY MR. EDGAR:

Q. Is it true that the non-stochastic limits that you refer in your testimony, the 50 rem by ICRP and the 30 rem by EPA are intended as annual limits for exposure to any single organ for radiation workers?

BY WITNESS COCHRAN:

A. The intent is to protect the public health and in doing that, the criterion that they have established in an annul limit.

MR. EDGAR: I move to strike the answer on the grounds that it is non-responsive.

JUDGE MILLER: It is not responsive. It will be stricken.

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Restate the question if you wish to pursue it.

BY MR. EDGAR:

Q. Do you agree that the 30 rem non-stochastic limit recommended by EPA and the 50 rem non-stochastic limit recommended by ICRP are annual limits for protection of radiation workers?

BY WITNESS COCHRAN:

A. Yes.

Q. Dr. Cochran, if -- and this a hypothetical -- if the recommendation in your testimony at the top of Page 25 is applied, that is, to apply either the ICRP non-stochastic limit or the EPA non-stochastic limit, if that were implemented by the NRC Staff or the NRC in connection with selection of Part 100 dose guidelines, what would that make the thyroid dose value?

JUDGE MILLER: Can you answer that, Dr. Cochran? Do you have the elements in mind?

WITNESS COCHRAN: Yes. It would depend on the extent to which they implemented it. If it were implemented for thyroid, it would be,the value would be 30, if they took the EPA approach or 50 if they took the ICRP approach.

BY MR. EDGAR:

Q. Right.

And thus it would change the 300 rems now set forth in 10 CFR Part 100; is that correct?

BY WITNESS COCHRAN:

A. If it were applied to 10 CFR 100 for the thyroid value, it would.

Q. May I refer you now to the second paragraph on Page 29?

You make reference to a document which is entitled Atomic Energy Commission ACRS Comments on Site Criteria For Nuclear Reactors, AECR 2 /23, December 10th, 1960 at Page 3.

BY WITNESS COCHRAN:

A. Yes.

Q. Do you believe that that document shows that ACRS actually proposed site suitability guidelines values of 25 rems to the whole body, 300 rems to the thyroid?

BY WITNESS COCHRAN:

A. The 10 CFR 100 regulations were adopted subsequently and some of the guideline values stated here were adopted in those but not the 25 rem to the bone or lung.

MR. EDGAR: I move to strike the answer as non-responsive.

JUDGE MILLER: The answer will be stricken. Now restate the question.

Listen to it, Dr. Cochran.

BY MR. EDGAR:

Q. I'm referring you to that ACRS document and now let me read you the first sentence of this portion of your testimony. I quote:

"It is worth noting that when the ACRS first proposed site suitability guideline values, it selected 25 rems to the whole body, 300 rems to the thyroid and 25 rems to the bone and lung." The last phrase, " and 25 rems to the bone and lung." is underlined.

Now, do you believe that the documents you cite in support of that sentence shows that the ACRS actually proposed 25 rems to the bone and lung?

BY WITNESS COCHRAN:

A. That's my recollection, at the time -- as of the date of the letter.

Q. Let me ask you one other question.

What do you mean by proposed?

JUDGE MILLER: As used in that quoted portion, Dr. Cochran.

BY MR. EDGAR:

Q. As used in your testimony?

BY WITNESS COCHRAN:

A. I mean -- you have to put this in context.

JUDGE MILLER: Hold it.

We'll take a recess and get it out of context and maybe get a more direct response.

Ten minutes.

(Short recess.)

/ / /

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JUDGE MILLER: Okay. Let's take our seats, please.

MR. EDGAR: Should we restate the question?

JUDGE MILLER: Yes, let's have the question restated, please.

BY MR. EDGAR:

Q Do you believe that the letter cited in your testimony shows that the ACRS actually proposed site suitability guideline values of 25 rems to the whole body -- excuse me -- 25 rems to the bone and 25 rems to the lung?

MS. FINAMORE: Your Honor --

MR. EDGAR: No, wait a minute. I'm giving him the -- That's just to refresh.

The question is: In your testimony what do you mean by the term "proposed"?

BY WITNESS COCHRAN:

A I do not have the letter with me. I would have to look at it to refresh my memory at the time I wrote the testimony.

Q Do you know what you mean in your testimony by the term "proposed"?

MS. FINAMORE: Objection. I believe he just answered that question.

JUDGE MILLER: Overruled.

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WITNESS COCHRAN: I mean that set forth the values that were identified in that sentence, 25 rems to the whole body, 300 rems to the thyroid, 25 rems to the bone and the lung, in the context of assessing sites or assessing the risks associated with exposure to the public under postulated accident conditions.

MR. EDGAR: I move to strike the answer as non-responsive.

JUDGE MILLER: It is not responsive and will be stricken.

The question is: What did you mean, as now you can best recall it, by the word "proposed" in that context?

If you can't answer, you may indicate --

WITNESS COCHRAN: Well, the -- I don't understand why my answer was unresponsive. I said --

JUDGE MILLER: Well, now you're arguing. Now it's argumentative. So we'll strike that.

Let's go back to ground zero. What, if anything, did you mean when you used the term "proposed" in that context? If you can't tell us --

WITNESS COCHRAN: Set forth in the letter.

JUDGE MILLER: All right.

BY MR. EDGAR:

Q Does it mean "recommended"?

BY WITNESS COCHRAN:

A. I would have to go back and look at the letter to refresh my memory.

Q. Do you know whether they recommended those values?

BY WITNESS COCHRAN:

A. I would have to go back and -- No.

Q. You don't know?

BY WITNESS COCHRAN:

A. Not without refreshing my memory.

JUDGE MILLER: All right. He has indicated that he doesn't know. Go ahead.

MR. EDGAR: I'd like to have marked for identification a copy of a letter dated December 10, 1960 to the Honorable John A. McCone, Chairman, AEC, from Leslie Silverman, Chairman, ACRS.

It is a copy of the document cited at Page 29 of Dr. Cochran's testimony.

I would ask that it be marked for identification as Applicants' Exhibit 33.

JUDGE MILLER: It may be marked.

(The document above-referred to was marked as Applicant's Exhibit No. 33 for identification.)

MR. EDGAR: We have a problem with the quality

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of the copy, but the Staff has a good quality copy. I'll hand that to the witness so that he's not placed at any disadvantage.

JUDGE MILLER: Very well.

BY MR. EDGAR:

Q Do you have before you Applicants' Exhibit 33?

BY WITNESS COCHRAN:

A Yes, I do.

I've got an extra page, but I assume that's not inadvertent.

Q Is that, in fact, the document you rely upon in your testimony at Page 29?

BY WITNESS COCHRAN:

A Let me check it.

Yes, that is the document.

JUDGE MILLER: What is the date that appears on your copy, Dr. Cochran? Ours isn't that plain.

WITNESS COCHRAN: I believe it's December 13th.

BY MR. EDGAR:

Q Dr. Cochran, in the -- well, the bold copy or the better copy that you have at the witness table -- does it say December 13th?

BY WITNESS COCHRAN:

A Yes. Which might indicate an error in my date on my -- in my testimony, which is noted as the 10th.

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But it is the AEC-R 2/23 -- Well, I cannot read the date of the cover memorandum, but it would have had to have come afterwards.

It's December 13th. My testimony should be corrected so that December 10 reads December 13.

JUDGE MILLER: Very well.

WITNESS COCHRAN: On Page 29.

MR. EDGAR: Your Honor, my identification of the document should be corrected to reflect that the document is dated December 13th and not December 10th.

JUDGE MILLER: Very well. Both corrections will be made to the record.

WITNESS COCHRAN: That is the document.

BY MR. EDGAR:

Q. Do you agree that the following is an accurate statement from the first page of Exhibit 33, and I quote from the second paragraph on the first page.

"While the Advisory Committee on Reactor Safeguards believes that it would be unwise to publish detailed quantitative site criteria in a regulation at this early stage of technology, we have provided in an attachment to this letter criteria which should be useful in the selection of sites for nuclear reactors."

Is that an accurate statement?

/

BY WITNESS COCHRAN:

A. Yes.

Q. I refer you to the attachment to that letter, to Exhibit 33, dated December 13, 1960, and in particular to the second page of the attachment. In the --

BY WITNESS COCHRAN:

A. Which page?

Q. The second page of the attachment.

BY WITNESS COCHRAN:

A. I have it in front of me.

Q. Under the caption, "Numerical Values," is it an accurate statement in the letter --

BY WITNESS COCHRAN:

A. Wait a minute. That's on Page 3, I believe.

Q. It's on Page 3 of Exhibit 33, Page 2 of the attachment.

BY WITNESS COCHRAN:

A. I have it.

Maybe you could come over here and straighten me out, Mr. Edgar. I only see a Page 3 at the bottom of the page, if I have the one you're referring to.

Q. All right. Then we're properly oriented.

I'm looking toward the middle of the page. There is a caption entitled "Numerical Values."

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BY WITNESS COCHRAN:

A. I have that.

Q. And if I count forward, the first page of Exhibit 33, including the first page, one, two -- it is the third page of Exhibit 33.

Under "Numerical Values," have you read the text on the rest of Page 3?

BY WITNESS COCHRAN:

A. Yes.

Q. Have you had a chance to review that?

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BY WITNESS COCHRAN:

A. Yes. I -- Probably I would like to read it again very quickly.

Q. Yes, please.

BY WITNESS COCHRAN:

A. I have read through the page.

Q. Do you believe that the ACRS endorsed the validity of guideline values of 25 rem to the bone or lung?

BY WITNESS COCHRAN:

A. Well, I believe the letter speaks for itself. They recommend these values in the paragraph marked one, with the caveats in the above -- you know, with the caveats in the above paragraph.

MR. EDGAR: I move to strike the answer as non-responsive. The question was as to the validity.

JUDGE MILLER: We'll let the answer stand. We do believe that the Board can read the letter, read the testimony.

I think no further comment is necessary.

MR. EDGAR: All right.

BY MR. EDGAR:

Q. May I refer you to the text in your testimony, the bottom of Page 29, going over to the top of Page 30.

/

BY WITNESS COCHRAN:

A. Yes.

Q. You discuss the 40 CFR 190 standards.

BY WITNESS COCHRAN:

A. Yes.

Q. Do you agree that these standards apply under conditions of normal operation?

BY WITNESS COCHRAN:

A. Yes, I do.

Q. Do you believe that these standards apply to planned releases of radioactivity?

BY WITNESS COCHRAN:

A. Yes, I do.

Q. Do you agree that the standards were based upon -- or that -- Let me strike that.

Do you agree that the basis for establishing these standards included the effectiveness and cost of the technology available to mitigate risks through effluent control?

BY WITNESS COCHRAN:

A. I believe some consideration was given to that.

Q. Were these standards based on the so-called "as low as reasonably achievable principle"?

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10-10

BY WITNESS COCHRAN:

A. In part.

Q. In part? Is it a fair statement that these standards were not based purely on biological considerations?

BY WITNESS COCHRAN:

A. Yes.

Q. Do you agree that the ICRP-26 weighting factors provides a measure of the relative radiosensitivities of various human body organs?

BY WITNESS COCHRAN:

A. An inaccurate one, yes.

Q. Without accepting the values, do you believe that that is an accurate description of what they are -- of their measure?

BY WITNESS COCHRAN:

A. What do you mean by a "measure"?

Q. All right. You gave me a yes answer. I'll strike the question and move on.

Do you believe that standards, such as the EPA 40 CFR 190 standards, which are based in part on ALARA principles and are not entirely based upon biological evidence, provide a rational basis --

BY WITNESS COCHRAN:

A. Excuse me. Would you start over? I'm losing

10-11

you.

Q Let's make it simple. In your testimony you say that the 40 CFR 190 standards recommend 25 rem to the lung and bone; is that correct?

BY WITNESS COCHRAN:

A I'll have to refresh my memory. If you would point out --

Q At the top of Page 30, the second sentence.

BY WITNESS COCHRAN:

A Yes. 25 millirem to the whole body and 75 millirem to the thyroid and 25 millirem to all organs.

Q I take it that in the context of this testimony, you believe that the dose guideline values for lung and bone should be the same, based upon your analysis of 40 CFR 190?

BY WITNESS COCHRAN:

A No.

Q Let me read the rest of your testimony. Are you making the conclusion that the lung and bone surface limits in the dose guideline values should be consistent with the ratio of lung and bone limits in 40 CFR 190?

BY WITNESS COCHRAN:

A No.

Q In your opinion, it is not appropriate for the lung and bone surface values to be the same for the

10-12

dose guidelines recommended by the Staff in the site suitability report; is that correct?

BY WITNESS COCHRAN:

A. Would you repeat your question, please?

Q. All right.

Do you believe that the lung and bone surface values for the site suitability dose guidelines should be the same?

BY WITNESS COCHRAN:

A. No.

Q. And it's your opinion that you haven't recommended that they be the same in this testimony?

BY WITNESS COCHRAN:

A. In terms of the testimony placed in context, that's correct, and in the -- if you read the entire testimony. If you try to pick out a little piece of it and try to make it stand alone, you'll be misrepresenting the testimony, as I believe your line of questions attempts to do.

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11-1 m

MR. EDGAR: I move to strike that answer.

JUDGE MILLER: It will be stricken. The latter portion will be stricken, the characterization.

Now move ahead.

MR. EDGAR: All right.

We have no further questions at this time.

JUDGE MILLER: Very well. Staff.

MR. JONES: We have a few questions.

CROSS-EXAMINATION

BY MR. JONES:

Q. Dr. Morgan, if one assumes that deposition outside of the containment does not occur for the purposes of computing bone doses, would that assumption lead to a measure of conservatism in the computed doses?

BY WITNESS MORGAN:

A. It depends on the chain of assumptions which precede that. In those assumptions which the Staff made, it would lead to a lesser dose if there were no re-suspension and no deposition. But I don't buy that.

I don't believe they have treated the dose from the Sodium-24 activation and its immediate fallout and the immediate casualities from very high gamma dose, such as we had at Test Bikini, where you had high sodium activation in the sodium with the water.

Now there, of course, the only sodium ions

that the neutrons could find when they were thermalized was in the salt water.

But here you have, admittedly, a swimming in a liquid sodium, and all of those neutron essentially -- or a large fraction of them -- have been absorbed and reached equilibrium -- the short-lived sodium.

So I believe my answer would have to be qualified.

Q Dr. Morgan, if one assumes that a release from the primary to the secondary containment were to go directly through the annulus filtration system rather than being dispersed within the air in the annulus region, would that lend conservatism to a computation of doses?

BY WITNESS MORGAN:

A. If you mean filtering out some of the radioactive contamination, that would, of course, be the inverse. It would tend to remove contamination.

Q No. What I'm referring to is if you assumed that the release from the primary containment goes directly to the filtration system, rather than going to the filtration system after it has been dispersed with the air in the secondary containment, would that not be a conservative assumption?

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11-3

BY WITNESS MORGAN:

A Yes.

Excuse me.

JUDGE MILLER: Yes.

WITNESS MORGAN: You used what could be -- lead to a double negative. You said that would not. I meant to -- My answer was yes. By "yes," I meant it would lead to conservatism. But you had a "not" in there.

So I interpreted what you meant and answered not what you said.

JUDGE MILLER: Okay.

(Laughter.)

JUDGE MILLER: If that's what he wants, I suspect he'll agree with you.

MR. JONES: I understand your answer.

WITNESS MORGAN: It has been a long time since I've studied Latin and Greek and English. I sometimes use double negatives, and not -- when I prefer not to.

BY MR. JONES:

Q If you could turn to Page 18 of your testimony, please.

In the first paragraph there, the first sentence, you indicate that "These data indicate that using the newer models could increase the dose due to a particular

11-4

plutonium (or other transuranic) isotope by a factor between 0 to 10 ...."

Which data are you referring to when you say "these data"?

BY WITNESS MORGAN:

A. The data in the table above that, just preceding that, Table 4, Page 18.

Q. And can you point out for us specifically which data in that table would give you the potential factor of ten difference?

BY WITNESS MORGAN:

A. Yes. In my book, 4 times 10^{-11} to the lung is quite different from some of the other assumptions. Well, let's take bone.

Maybe we had better concentrate, say, on Plutonium-239.

In Table 4, in the second column you have values for the weekly retention and yearly retention indicated by "W" and "Y."

If you follow across, going from the "W" column -- the "W" line -- you have a change by a factor of two. That's what I referred to.

For the yearly value the line indicated by "Y," you have a change from 4 times 10^{-11} to 4 times 10^{-12}, which means a nonconservatism in ICRP-2 of a factor of

ten. It's ten times larger.

Q. But the -- If I'm reading this correctly, the figure in the -- what would be your second column that you referred to is for a dose to the lung and the figure in the last column is for a dose to the bone surface; is that correct?

BY WITNESS MORGAN:

A. Yes. I think when you inhale plutonium that you look at the dose to all the organs and, presumably, they picked out the worst -- the largest dose. In this case it was the lung -- rather the bone surfaces.

And I think they're somewhat remiss in not looking at the liver. I would have included that, since ICRP has indicated that for chronic exposure, certainly the liver is just as much at risk as the bone and perhaps more so.

Data on that arose from Fouma and others that have indicated that.

Q. Dr. Morgan, did you assume in evaluating the adequacy of the Staff's dose guidelines in the 1982 site suitability report that the Staff used the maximum permissible body burden figures in calculating those dose guidelines?

BY WITNESS MORGAN:

A. They used what -- what did you say? The

11-6

maximum --

Q. The maximum permissible body burden figures.

BY WITNESS MORGAN:

A. The maximum permissible body burden figure, of course, would have to refer in your question to Handbook 2, because the other handbooks referred to, 26 and 30, et al., don't use that concept.

The Staff used that when it was convenient, and on other occasions -- I can show other occasions they claim they made use of 26 and 30.

Q. And that's with respect to the 1982 site suitability report -- your answer?

BY WITNESS MORGAN:

A. (No response.)

Q. You said sometimes the Staff used one and sometimes --

BY WITNESS MORGAN:

A. Yes.

Q. You are referring to --

BY WITNESS MORGAN:

A. I would like, if I had time, to go through the calculations, and I can show that the doses were actually orders of magnitude larger than the Staff or ORNL claim.

Q. No, I'm just trying to clarify your answer

11-7

and make sure we're talking about the 1982 site suitability report and not the earlier site suitability report.

BY WITNESS MORGAN:

A. That's right. But I would like very much to show the Judges that the doses were much larger than indicated by the present calculations, if I had that opportunity.

MR. JONES: I have no further questions.

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JUDGE MILLER: Any redirect?

MS. FINAMORE: Yes. I'd like to ask for a recess.

JUDGE MILLER: Well, I'd like to run until lunch and be through. I think we'll -- No, we've had recesses now. It's time to move on and conclude. We're about through.

MS. FINAMORE: I would just ask for two minutes of recess.

JUDGE MILLER: All right. We won't recess, but you can go talk to whoever you want to for two minutes.

We'll stay in place because we lose time when we disperse.

(A short recess in place was taken.)

JUDGE MILLER: All right. We will bring this out on the record when we finish with the panel.

Redirect.

REDIRECT EXAMINATION

BY MS. FINAMORE:

Q Dr. Cochran, you were asked earlier about your opinion of the objectives of the EPA proposed guidance. Did you have anything to add to that?

MR. EDGAR: Objection. He was not asked for that.

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MS. FINAMORE: That's my understanding of what your questions were, Mr. Edgar, his opinion of what the objectives were of the EPA --

JUDGE MILLER: We don't recall that he was asked that.

I think part of the problem was that that was a matter that was being interjected.

MR. EDGAR: I did not ask him about the EPA proposed guidance, which is Exhibit 10 -- Intervenors Exhibit 10.

MS. FINAMORE: You specifically him if he thought that the objectives of the EPA guidance were a particular matter. And then he was attempting to explain his understanding of the objectives of those proposed guidance.

MR. EDGAR: I asked those questions of Dr. Cobb, I'm sure of that -- and Dr. Morgan.

MS. FINAMORE: No, you also asked Dr. Cochran.

WITNESS COCHRAN: I believe you asked me whether they were -- the objectives, whether they established an annual limit.

MR. EDGAR: I --

JUDGE MILLER: All right. We're not entirely clear, because the question was asked at least of other

11-10

witnesses.

Do you recall being asked that, Dr. Cochran? Insofar as you're not going into matters that you've already testified to, you may answer.

WITNESS COCHRAN: Well, I just wanted to clarify that I believe these annual limits can be used not for the precise purpose that they were defined, but for the purpose of giving some indication of where one should properly establish the guideline values for plutonium in lung to protect the public health, under 10 CFR 100.

JUDGE MILLER: Very well.

Anything further?

BY MS. FINAMORE:

Q Dr. Morgan, you were questioned earlier about 10 CFR Part 20. Can you explain whether those particular regulations are relevant to your testimony in any way?

MR. EDGAR: Objection.

JUDGE MILLER: Let him answer.

Can you answer that, Dr. Morgan?

WITNESS MORGAN: Yes, I can.

JUDGE MILLER: You may.

WITNESS MORGAN: Thank you.

The values are relevant to Title 10, Part 20, because Tables 1 and 2 in these publications

11-11

use the values essentially from ICRP 2, which are based on these assu[illegible]cions.

You use almost identical numbers, as a matter of fact.

JUDGE MILLER: Very well.

Anything further?

MS. FINAMORE: Yes.

BY MS. FINAMORE:

Q You were questioned earlier regarding your views on the proper use in the site suitability report of ICRP-2, 26 and 30. Did you have anything to add to that?

MR. EDGAR: I object to the form of the question.

JUDGE MILLER: Sustained.

BY MS. FINAMORE:

Q Dr. Morgan, you stated earlier that you believed that the Staff inaccurately applied in certain portions of its calculations ICRP-2, 26 and 30. Do you have anything to add to that?

BY WITNESS MORGAN:

A Yes --

MR. EDGAR: Objection.

JUDGE MILLER: Sustained.

The objection is sustained. Next question.

BY MS. FINAMORE:

Q Dr. Morgan, you stated earlier that you felt that the Staff inaccurately applied ICRP-2 to its calculations in the site suitability report. Do you have anything to add to that?

MR. EDGAR: Objection.

JUDGE MILLER: Sustained.

BY MS. FINAMORE:

Q Dr. Morgan, you were questioned earlier as to why you believed the Staff had inaccurately applied ICRP-26 to its calculations in the site suitability report; is that correct?

BY WITNESS MORGAN:

A Yes.

MR. EDGAR: Objection. I move to strike the answer.

JUDGE MILLER: It may stand. The record shows in voluminous detail that that's what happened. The description is at great length. That's why we're sustaining the objection.

What's your question?

BY MS. FINAMORE:

Q Do you have anything to add to your answer to that question?

MR. EDGAR: Objection.

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JUDGE MILLER: Sustained.

MS. FINAMORE: I don't believe the question is leading.

JUDGE MILLER: That's not the objection.

MS. FINAMORE: I didn't hear the grounds for the objection.

JUDGE MILLER: But it's repetitious and redundant, any figure of speech that you want to use. It has been very fully and thoroughly covered. We permitted Dr. Morgan to. We're glad to have the record, but we think that it's much beyond the scope of redirect examination.

MS. FINAMORE: I believe that --

JUDGE MILLER: This is redirect.

What's your question?

MS. FINAMORE: I believe there was one portion of that answer that was not covered.

JUDGE MILLER: Well, if there was, it was the only portion not covered. Objection sustained.

(Laughter.)

JUDGE MILLER: Now if you want to get into something that's reasonably triggered and not covered, yes. But we don't regard this as being in that area.

It's not the function of either the witness or the counsel -- "I have something more to add" -- that's

11-14

not the function of redirect, not at all.

BY MS. FINAMORE:

Q Dr. Morgan, you stated earlier that you did support of the use of ICRP-26 and 30 in certain instances. Can you explain what those instances are?

MR. EDGAR: Objection.

JUDGE MILLER: Sustained.

BY MS. FINAMORE:

Q Dr. Morgan, you stated earlier that you believed the use of ICRP-26 was correctly used by the Staff in certain contexts. Did you explain what those contexts were?

MR. EDGAR: Objection.

JUDGE MILLER: Sustained. The record will show that he did.

We're being very indulgent, you'll notice. We're letting you ask the same question. It's repetitious, monotonous and redundant, and we're going to cut everything off very shortly.

MS. FINAMORE: I believe the question was --

JUDGE MILLER: If you've got anything --

MS. FINAMORE: -- very specific and focused in response to your sustaining of the objection. I'm trying to elicit one particular fact from Dr. Morgan. I am trying to find a way in which it can be specific and

11-15

within the scope of redirect. This is not the same question that I asked earlier, and I respectfully ask that it be noted that it be a different question and not repetitious, and that the witness be permitted to answer within the scope of redirect.

JUDGE MILLER: What was the difference? Tell me with specificity what the difference was.

MS. FINAMORE: Well, I began by asking --

JUDGE MILLER: No, not what you began. Tell me right now. What are you specifically asking that hasn't been covered completely and thoroughly.

MS. FINAMORE: Okay. All Dr. Morgan said earlier was that he -- he gave a very detailed explanation of the faults he saw in ICRP-26 and 30.

He did not explain why, if any, he felt they were properly applied. He merely stated --

JUDGE MILLER: Our memory is that he did, that he gave the manner in which they were properly applied as well. He gave a balanced judgment. He gave it at great length.

You're not asking anything new. Now that's the function of redirect. It isn't just regurgitation. It isn't repetition, and it isn't redundancy.

Now if you want to focus on something, you're going to have one more question. So think it over.

12-1
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MS. FINAMORE: I have no further questions.

JUDGE MILLER: Thank you. I take it there's nothing further.

MR. EDGAR: I have one on recross and it's just --

JUDGE MILLER: Well, what does it bear on, now, we want to make sure we --

MR. EDGAR: Well, Dr. Cochran, in answer to redirect, identified the proposed guidance, and I want to be sure we've got it indexed to the right source.

My question is going to be, did he refer to the 40 CFR 190 guidance, and if not, to what. That's all.

WITNESS COCHRAN: I don't recall.

JUDGE MILLER: Well, in that event, you saved us a total of --

MR. EDGAR: Okay. Fine.

JUDGE MILLER: Thank you, gentlemen.

Oh, I'm sorry, Judge Linenberger has some questions. As you were.

BOARD EXAMINATION

BY JUDGE LINENBERGER:

Q. Very briefly, to you, Dr. Cochran, first off, I recollect during the early phases of questioning of Dr. Morgan this morning there was an indication that you played a role in the formulation of Dr. Morgan's testimony,

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and I want to understand, with that backdrop, the context in which the Board ought to accept, on Page 30 of your prefiled testimony, Intervenors' exhibit marked for identification as No. 4, the several instances in which you state that you agree with Dr. Morgan's testimony, you agree with Dr. Morgan's conclusion, endorse Dr. Morgan's statements. In other words, to put it bluntly, if the situation is that you wrote Dr. Morgan's testimony then I want to understand what it is you want us to do about those statements on Page 30; if indeed this is a misrepresentation of the situation, then I would like you to explain that also. So you have the microphone at this point.

A. Thank you. As Dr. Morgan indicated, he's an extremely busy man, even though he -- well, he's extremely busy, and I asked him to assist in this case and told him that I would do what I could to assist him in the preparation of some of the testimony so that it would take some of the burden off of him, and I did assist in part but not all of his testimony, and that assistance was in the form of collecting and copying and delivering to Dr. Morgan all of the appropriate citations and reference material so that he could make his own judgments, and I drafted a general outline of where I thought the Staff arguments were weak and where I would hope he would focus on them and made it very

12-3

clear that he was not to accept any of my language, that this was his testimony and that he should strike anything from my draft and add any thoughts of his own and that's what he did.

And so then the next question was, should we repeat the essential arguments in my testimony all over again, and I didn't see any value in another layer of duplication and therefore simply cited to the aspects of his testimony where I was in agreement and added additional language in my testimony where I disagreed with -- or had additional views on the same subject areas.

Q. Dr. Cochran, let me refer you explicitly to the -- on Page 30 to the only paragraph that has its beginning on Page 30, and there are specific numbers in that paragraph that you express agreement with.

I'd like to know, just going number by number, three millirads per year to the bone, 150 rems to the bone, 35 rems to the lung, number by number through there, did you originate any of those numbers in Dr. Morgan's testimony or, as far as you know, did Dr. Morgan originate those numbers, or did Dr. Morgan extract those numbers from references you provided?

BY WITNESS COCHRAN:

A. I don't -- I don't recall. I provided Dr. Morgan with the EPA documents. Is your line of

12-4

questioning on the procedure as opposed to the interpretation of my testimony at this point? I'm somewhat confused on -- because I would give a different answer if I knew the nature of the question.

Q You stated your agreement, on Page 30, with Dr. Morgan's testimony as it relates to several specific --

BY WITNESS COCHRAN:

A Numbers.

Q -- numbers that appear on Page 30 of your testimony. The underlying question is, what credibility would you like us to give your statement of agreement with Dr. Morgan in view of the fact that it has been stated --

BY WITNESS COCHRAN:

A I understand.

Q -- that you participated considerably in the preparation of Dr. Morgan's testimony?

BY WITNESS COCHRAN:

A I think the appropriate interpretation would be that I have -- in my testimony have -- recognizing that there are now no guideline values for bone and lung, have attempted to set forth various alternatives or ways one could examine or go about selecting a value, and it -- and I started with the higher values and was working -- sort of working down and at the point of the EPA -- with regard to the EPA recommendations, I endorse, as does Dr. Cobb and

12-5

Dr. Morgan, the view that those guideline values shouldn't be accepted -- I mean shouldn't be exceeded. However, I go on to say how I would further amplify my views on that.

Now, I don't know precisely -- I presume Dr. Morgan and I would part ways beyond that point. I don't know his precise views on what quality factors he would use, or alternatively what dose guideline values he would use, but we --

Q Thank you, Dr. Cochran. My question didn't go to quality factors, so perhaps we'll just move on.

Dr. Morgan, I would like to refer you to one statement that appears at Page 5 of your testimony. It's the last half of the third sentence from the bottom of the page on Page 5, where you state, and I quote, "It is difficult to understand how any objective analyst could conclude that a core meltdown or a nuclear explosion in a reactor similar to the CRBR is not credible," end of quotation.

Now, that difficulty of understanding that you express there follows a mention of accidents that have occurred in several other facilities. That expression of difficulty to understand how an objective analyst could make a conclusion about CRBR would lead one to think that whoever wrote that statement had done some analytical comparison of the accident progression, reactor kinetics,

12-6

engineering design features of these various facilities that have been quoted just above in order to decide that there's no way you can conclude that the CRBR won't do the same thing, or indeed conclude that CRBR will have a credible accident.

Now, did you perform that kind of kinetics and design analysis of ERBR-1, FERMI, Three Mile Island and make a comparison with engineering considerations of the Clinch River in order to reach this conclusion that it's difficult to understand how an analyst could avoid anticipating a nuclear explosion at Clinch River?

BY WITNESS MORGAN:

A. I did not go through the engineering calculations. I had only one day to prepare this testimony and get it typed and to read over the material. As I indicated earlier, I'm busy on other programs.

Q. Well, I care not about how much time you had or didn't have, but the statement would lead one to believe that some kind of an analysis has been made of other accident situations and sufficiently compared with the proposed design of Clinch River to lead that person to conclude that Clinch River is likely to experience a serious, or as stated here, a nuclear explosion.

Now, I'm just trying to understand whether you have brought professional judgment to bear in making that

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statement, because it involves rather complex engineering considerations and comparisons, or whether this is a qualitative -- well, I'll say emotional reaction to the prospect of Clinch River design.

BY WITNESS MORGAN:

A. I don't believe, as you say, it's an emotional response. It's a conclusion arrived at over a period of more than a decade, studying the development of this system of the liquid metal fast breeder systems. It's a conclusion based on the relative amounts of plutonium and on the question of proliferation, and experience with other reactor accidents, breeders in particular, the Russian fire with sodium, all these things were put into the pot in arriving at this conclusion.

Q. Excuse me. I lost you there because I heard you mention the word proliferation in conjunction with a consideration of whether, from an engineering point of view, Clinch River might behave like EBR-1. I just didn't understand how proliferation got in there.

BY WITNESS MORGAN:

A. Well, your question was rather long and did not focus solely on the reference -- relationship between EBR-1 and --

Q. Which is what your testimony does here?

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BY WITNESS MORGAN:

A. Not just that; that is taken out of context, quite frankly.

JUDGE LINENBERGER: All right, sir. Perhaps I have taken it out of context, and my apologies for that.

I have no further questions.

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JUDGE MILLER: Dr. Hand?

DR. HAND: Nothing.

MS. FINAMORE: I'd like to offer into evidence Intervenors' Exhibits 4, 8 and 9.

JUDGE MILLER: Any objections?

MR. EDGAR: Yes.

We move to strike on Intervenors' Exhibit 8, we move to strike the following:

Page 2, the paragraph enumerated 1.

Page 3, the second full paragraph, five lines from the bottom the statement dealing with the findings of the human plutonium burden study.

Page 4 through the first paragraph on Page 5, Page 5 --

JUDGE MILLER: Wait a minute.

What was 4?

MR. EDGAR I'm sorry.

All of Page 4.

JUDGE MILLER: All of Page 4. All right.

MR. EDGAR: Up through the first paragraph on Page 5.

JUDGE MILLER: All right.

Next.

MR. EDGAR: Page 5. In the first full paragraph, the second sentence --

JUDGE MILLER: Which reads what?

MR. EDGAR: That Page 5, first full paragraph, second sentence. It starts with: "This conclusion --

JUDGE MILLER: Okay .

MR. EDGAR: -- follows logically "

JUDGE MILLER: Okay.

That entire sentence?

MR. EDGAR: Yes,sir.

JUDGE MILLER: Anything else?

MR. EDGAR: Page 8.

JUDGE MILLER: We don't have Page 8.

MR. EDGAR: Second full paragraph.

JUDGE MILLER: Page 8, second full paragraph.

MR. EDGAR: The latter item we object to on the grounds of relevance. It deals with widespread use of LMFBRs.

JUDGE MILLER: Wait a minute, now.

You've been giving me paragraphs and now you're talking about something else.

MR. EDGAR: All right.

Now, I'm going to sort the grounds out. I have two grounds.

JUDGE MILLER: Will this conclude the portion you are moving to strike?

MR. EDGAR: That's correct.

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JUDGE MILLER: Okay.

MR. EDGAR: On that exhibit.

The latter reference that I gave to Page 8, second full paragraph, I move to strike on the grounds that it relates to matters of widespread use of LMFBRs which the Commission's August'76 decision struck from these proceedings as a relevant issue in the proceeding.

As to all of the other references, we object on the grounds that Dr. Cobb's report of the EPA Human Burden or Plutonium Burden Study was not furnished in a timely manner and we did not have a fair opportunity to review it.

JUDGE MILLER: Staff.

MR. JONES: The Staff has indicated earlier that we had no objection to the admission of it, subject to motions to strike, so we don't object to the --

JUDGE MILLER: These are the motions to strike, right now. The future is here.

MR. JONES: We would agree with Applicants on the portions they move to strike. We may have additional ones. We haven't gone through it in terms of the cross-examination that took place to--

JUDGE MILLER: Well, that's what I'm asking you now. We're getting ready to rule. This is your last opportunity.

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MR. JONES: The Board has indicated earlier that motions to strike may be in writing and --

JUDGE MILLER: No, no, no. We did that with reference only to the one matter where it was expressly asked. Everything else we're ruling as we go.

MS. FINAMORE: So, it's not the Board's order earlier?

JUDGE MILLER: Pardon me?

MS FINAMORE: It is also our understanding that the Board said that motions to strike would be permitted in writing at a later date.

JUDGE MILLER: We said that only as to one motion. Now, we've been telling you day after day, make your comments now. Your understanding is erroneous. You better correct it, if you've got it in your head. Your motions are now.

We're in a trial. We're ruling now on admissability.

MR.EDGAR : Our understanding is that the only one that was postponed and leave was granted was Applicants' Exhibit 1.

JUDGE MILLER: That's correct. That was a lengthy one. We didn't want to take the time. When we read through it, we heard some preliminary arguments. Everybody on Counsel's side was in agreement and the Board

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said, "Very well. On this one we will permit you to --". We said what we would do would be to admit the proffered testimony subject, however, to a motion to strike in writing setting forth grounds.

Now, that's the only thing we've given that indication on. If you reasoned from there, you reasoned fallaciously.

Other than that, we're in a trial and we're ruling that you go. I know I said that three times but it doesn't matter.

Now, let's get to the Staff, first of all.

MR. JONES: Under those circumstances, I think we would have to move to strike the entire testimony of Dr. Cobb on the basis of relevance.

I think it was established that it wasn't -- he didn't write the testimony, with respect to having read that contention and he did not connect them to NRC Regulations but related them to EPA and we did not see a connection made that would make the discussion of the proposed EPA Guidelines relevant to the contentions; so we move to strike the entire piece of testimony.

JUDGE MILLER: Do you have any grounds? I want to be sure have stated for the record all the bases of objections.

MR. JONES: May we have just a moment?

WITNESS COCHRAN: Excuse me, Judge Miller. Am I permitted to speak to Counsel?

JUDGE MILLER: Yes.

Just so you don't interrupt the proceedings.

MR. JONES: Also, we would add that there was a lack of demonstration of expertise to testify as to the requirements for guidelines for site suitability purposes.

JUDGE MILLER: Okay.

MS. FINAMORE: May I respond to those motions?

JUDGE MILLER: Yes.

MS. FINAMORE: Am I correct that the Staff did not move to strike on the grounds that it had no basis to examine the underlying documents?

JUDGE MILLER: That's correct. Staff did not include that as a grounds.

We'll overrule that contention, anyway. You're all even-steven on that. We know it was late but we think that the way it was susceptible to being handled, no one was prejudiced.

MR. FINAMORE: I would like to respond to two grounds, then.

First, that there is a lack of relevance and, second, a lack of expertise.

I believe that the testimony is relevant for

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the following reasons:

First of all, unlike Staff's assertion, Dr. Cobb did indicate that he had recalled reading Intervenors' Contention 11(d). Contention 11(d) states that the guideline values for permissable organ doses used by Applicants and Staff have not been shown to have a valid basis and I believe that that is the portion of the contention --

JUDGE MILLER: As far as the contentions on relevance are concerned, we're going to overrule the objections, primarily of Staff.

We're still going to have to go through, however, if our rulings don't encompass some of the specific pages that Mr. Edgar has identified, we may still have to go through that. Insofar as they are within the scope of our ruling --

MR. EDGAR: Let me understand your ruling.

The question of the unavailability of the documents was overruled -- that objection was overruled.

JUDGE MILLER: Yeah. We understand that and if we were proceeding -- if it was a murder trial or something --

MR. EDGAR: Right.

JUDGE MILLER: -- but nobody's going to get executed.

We think that Counsel are experienced and were

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able to handle the situation without undue prejudice, hence, we're going to overrule that as a basis for objection.

MS. FINAMORE: Am I correct, then, that the only motion or basis for a motion to strike now is the expertise of the witness?

JUDGE MILLER: Gosh, I don't know. You heard it.

MS. FINAMORE: We had three bases. I believe you overruled two of them. Correct me if I'm wrong.

JUDGE MILLER: I overruled relevance I know that. That's the Staff's.

Did you have another one besides that?

MR. JONES: Yes. We also stated we objected on the basis that he had not demonstrated expertise with respect to the site suitability guidelines.

JUDGE MILLER: Oh, yeah.

Let me indicate that while full expertise in everything was not shown, nonetheless we think that the witness Dr. Cobb, did sufficiently identify the subject matter and the substance of what he was talking about. So, we don't rule on technicality -- we try to get to the underlying merits and on that basis we think that he both had sufficient expertise for what he was testifying to and that he sufficiently related the subject of the EPA investigation, for example, to the substantive matter,

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regardless of the numbers and so forth of the NRC regulations and those matters. So, we're cutting through, in other words, form to substance, so we're overruling that objection , too, but I haven't had a chance now to go through the ones Mr. Edgar is --

MR. EDGAR: You've overruled all of mine with the possible exception of the last one on the widespread use of LMFBRs.

JUDGE MILLER: Okay. Let us address that.

MR. EDGAR: And if we categorize that as relevance or not, my reliance was on the August '76 decision,to the extent that it ruled that out.

JUDGE MILLER: Okay. I think then that we will overrule that one as well.

As you know, these are matters of substantial public interest and we want everybody to have a fair opportunity. On the other hand, we do have to keep things moving and that's why we, from time to time, use the principle that we warned you we would prevail in the courtroom. Nonetheless, we're going to see that everybody gets a chance to make a record.

Now, let us move now -- I take it there are no further objections, Counsel?

MR. EDGAR: Yes,sir.

MR. JONES: Yes.

JUDGE MILLER: Okay.

MR. EDGAR: Intervenors' Exhibit 9.

JUDGE MILLER: Nine? Dr. Morgan's testimony?

MR. EDGAR: Yes.

First full paragraph, Page 3.

JUDGE MILLER: Page 3, first full paragraph. Very well.

MR. EDGAR: First sentence, Page 4.

JUDGE MILLER: Page 4, first sentence.

I don't know why we've already got those marked. Dr. Hand must be perceptual.

Go ahead.

(Laughter.)

MR. EDGAR: All of Page 5.

JUDGE MILLER: All of 5.

MR. EDGAR: Through the top paragraph on Page 6.

JUDGE MILLER: To the top paragraph on Page 6.

MR. EDGAR: It's a partial.

Page 6, second -- under the caption Contention 2, second sentence of the second full paragraph --

JUDGE MILLER: "This presumably -- "?

MR. EDGAR: Yes.

JUDGE MILLER: Okay.

MR. EDGAR: And then the next sentence following that: "As I explained in my testimony --".

JUDGE MILLER: Okay.

MR. EDGAR: Page 7.

JUDGE MILLER: Seven.

MR. EDGAR: Second full paragraph on the page.

JUDGE MILLER: Yeah.

MR. EDGAR: Up through the top of Page 8, the entire continuation paragraph on Page 8.

Page 14.

JUDGE MILLER: .14.

MR. EDGAR: Second full paragraph. The first sentence and the citation thereto.

JUDGE MILLER: Okay.

MR. EDGAR: The grounds are, and I can separate the last ground out fromthe first because it is slightly different -- on the item on Page 4, relevance. Secondly, the qualification of the witness to interpret --

JUDGE MILLER: Relevance and what else?

MR. EDGAR: Lack of qualificationof the witness to render a valid legal opinion about the effect of the Board's order.

MS.FINAMORE: Which page are you referring to?

MR. EDGAR: I'm sorry. I said 14. It's Page 4.

MR. FINAMORE: Which Board order are you referring to?

MR. EDGAR: The one cited in the testimony.

JUDGE MILLER: The one the Board's ruling is cited in.

MR. EDGAR: I object on the grounds of relevance and materiality and, finally, on the grounds that the witness is not qualified to render an interpretation of a Board ruling.

JUDGE MILLER: Now, wait a minute. This is testimony?

MR. EDGAR: Yes.

JUDGE MILLER: That's stricken.

MR. EDGAR: All right.

MS. FINAMORE: Excuse me, Judge Miller. Are you just striking the citations to the Board order?

JUDGE MILLER: I'm striking the whole paragraph to which the citations are hooked on.

MS. FINAMORE: I believe the rest of the paragraph is a factual one.

MR. EDGAR: No. It's just the first sentence that I move to strike.

JUDGE MILLER: You've got one long sentence and the Board's order.

MR. EDGAR: Yeah.

JUDGE MILLER: It is that first full sentence through the April 14, 1982 order that's stricken.

MR. EDGAR: Now, all other items in the testimony

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that I identified in going through this list for Intervenors' Exhibit 9, I move to strike on the grounds that the witness had no qualifications to testify concerning the engineering elements, physics and knowledge of the CRBR general design features, so as to render any valid opinion concerning the issue of whether a CDA should be a DBA.

MS. FINAMORE: May I respond to that one?

JUDGE MILLER: Yes.

What was the first page that you are going to respond to? 4, is it?

MR. EDGAR: 3.

JUDGE MILLER: Okay. Go ahead.

MS. FINAMORE: Well, I believe that the same objections apply to all the pages cited by the Applicants; is that correct?

MR. EDGAR: Yes.

MS. FINAMORE: And they go the general question of whether or not the witness has qualifications to present those opinions; is that correct?

JUDGE MILLER: Yeah.

MR. FINAMORE: Okay.

Well, I --

JUDGE MILLER: Well, Page 3, there is a reliance upon what associates have told -- there is no way to

13-14

cross-examine an associate and so forth. We don't think it in any way impairs Dr. Morgan's judgment, because he's shown his qualifications and certainly they are extensive. However, the basis, as well as other things, including the conclusory nature, we will strike the first full paragraph on Page 3, starting off: "I believe there are --", and ending with, " -- Super Phenix breeder reactor."

That paragraph will be stricken.

Now, what was your next one? Your next one on Page 4.

MS. FINAMORE: Yes. Before --

JUDGE MILLER: Staff, I'm assuming that your objections are to the same extent and as extensive as the Applicants'?

MR. JONES: Actually, they are a little more extensive. We have one other portion of the testimony to strike. You can finish the Applicants, if you want or I can give them to you now.

JUDGE MILLER: Well, I don't know. We're letting Intervenors respond and they should have an opportunity to see the whole target --

MR. JONES: Okay.

JUDGE MILLER: -- that's being shot at.

MR. JONES: Okay, then, I'll indicate the one additional portion that we would move to strike and the

13-15

reason.

Beginning on Page 12, the second paragraph which begins, "Applicants have indicated --", and extends through Page 13, to Page 14 and ends with the reference to, "-- Health Physics 10, 151 to 169, 1964."that that would be the end of the first paragraph.

JUDGE MILLER: I'm sorry. I didn't get it. What was your last portion there? Was that the footnote?

MR. JONES: No. It's the reference on Page 1[illegible] which extends from Page 12 through Page 14.

JUDGE MILLER: The entire Page 13?

MR. JONES: To the end of the first full paragraph on Page 14.

JUDGE MILLER: On 14?

MR. JONES: And the reason is that it was established by the Applicants that the application is only for the fuel that has been analyzed and the Staff analyzed that fuel. It was established that it would take an amendment to use these fuels that are being discussed in this portion, therefore, this discussion of other fuels is not relevant to what's been proposed for the general size and type reactor of Clinch River.

MS. FINAMORE: I'd like to respond to that one.

JUDGE MILLER: Okay.

Well, are you going to waive your other

responses?

MS. FINAMORE: No. I can do them in whatever order you wish.

JUDGE MILLER: You can wait until they're all in and you can address them all.

MS. FINAMORE: I believe that this is the one --

MR. JONES: That is the conclusion of the Staff's motions.

JUDGE MILLER: All right.

Now, then, the next one to which objection has been made, we having ruled on Page 3, I think would be Page 4, would it not?

Was it the first sentence --

MR. EDGAR: The first sentence on Page 4.

JUDGE MILLER: Okay.

Now, what's your response to that?

MS. FINAMORE: Let me clarify for the record first, I believe the Applicants initially asserted that the sentence was not relevant; is that correct?

I have that on my notes. You objected on grounds of relevance.

JUDGE HAND: I'm missreading his page on that. We thought he meant 14 or something.

MR. EDGAR: We had some confusion. The ground asserted is lack of qualification.

MS. FINAMORE: Well, I think the record will show the extensive amount of qualifications of the witness here in the area of whether the core disruptive accidents should be credible.

He has a great deal of knowledge concerning accidents at other reactors, including the Three Mile Island reactor, and has specifically been selected as an assistant to a law firm to deal with that Three Mile Island reactor.

I think his extensive experience at Oak Ridge National Laboratory, his association with -- his present position as a Professor at Georgia Tech, his previous position at Oak Ridge National Laboratory and his 25 years of experience there with the development of the entire breeder reactor concept would serve to qualify him to make the kind of statements that he has already.

He indicated that he has reviewed an extensive number of documents on the Clinch River Breeder Reactor itself, up to and including this morning; and he is very familiar with accidents that have occurred previously; and he has been able to point to citations in the record where he has extensive knowledge of those reactors.

I believe that any objections to his qualifications would go simply to the weight that they be

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afforded, but they should be given some weight, given those extensive qualifications as he has indicated.

I don't think one must need to be a -- a nuclear reactor with a doctorate in order to have a reasonable, validated opinion that should be given some weight in this context.

I meant nuclear engineering.

I don't think there are too many people who are not employed and working on this project who would be qualified to speak to it. And I think the ones that do have the amount of experience that Dr. Morgan has should be permitted to enter their opinions and judgments into the record.

I believe they're based on valid experience.

JUDGE MILLER: We recognize, of course, that Dr. Morgan, has extensive experience, which we don't belittle in any way.

We think, however, as to this sentence and this belief as to the credible occurrence and the like that it requires an engineering approach, which we believe Dr. Morgan himself indicated he did not claim.

We, therefore, will strike the first sentence on Page 4, starting with, "Regarding Contention 1," and ending, "type as the CRBR." That will be stricken.

What's the next one?

14-3

MR. EDGAR: Page 5, all of it, up to the top of Page 6, the continuation.

JUDGE MILLER: What were the objections now to that?

MR. EDGAR: The same grounds.

JUDGE MILLER: The same grounds.

MS. FINAMORE: Okay. In response to that, I think the testimony itself indicates that Dr. Morgan has been following this particular topic ever since the 1940's. That is for 40 years.

He has been interested in whether or not those accidents should be considered credible. He has looked into the question of whether or not this country should be pursuing the liquid metal fast breeder reactor, or other types of fast breeder reactors, such as the molten salt reactor.

I believe that he has been extensively involved from the beginning.

His testimony here does not go beyond the scope of his experience. In the sentence when he talks about accidents that have already occurred at other reactors, he was able to give complete citations to what he was referring as the underlying basis for those documents.

I believe that to that extent he has indicated that he has knowledge and experience to back up the

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statements that he has made.

These are all a matter of public record, and I don't believe one has to be a nuclear engineer to make the statement that accidents have already occurred at the EBR-I, Fermi-I and Three Mile Island-II accident.

I believe that is a matter of public knowledge and should not be stricken, if stated by someone who is not a nuclear engineer.

JUDGE MILLER: Well, I'm afraid we're going to sustain the objection and make the same ruling on this for the same reasons that we just gave you on the preceding page; namely, there is no question about the qualifications of Dr. Morgan or his very extensive participation and his experience as described.

But we do not think that it is a sufficient basis for expression of the opinions and lacks the appropriate requisite engineering basis and judgment, which is not advanced, as a matter of fact, by the witness in the subject of expertise.

As far as a non-expert opinion, we don't regard these matters as being relevant to the Board.

Now what's the next one?

MR. EDGAR: Page 6 under the caption, Roman two, the second paragraph, the last two sentences, the same grounds.

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MS. FINAMORE: The first sentence that Applicants cite states -- in relation to the Staff site suitability source term, "This presumably is based on Staff's position that a core meltdown and possible nuclear explosion is not a credible accident in an LMFBR."

All Dr. Morgan is saying is, in effect, a restatement of the statements of the Staff itself in the site suitability report.

The Staff itself has stated in its prefiled testimony and on the stand that it believes that a core accident meltdown or core disruptive accident is not credible; and that is the basis for its source term.

It does not require an expert opinion to just draw a reference from the testimony of the Staff.

JUDGE MILLER: The Board is going to sustain the objection.

Once again, we believe that that calls for an engineering judgment, which the members of the Board, especially the technical members, feel is lacking .

So we will sustain the objection. We will strike the two sentences which appear on Page 6 within the body of the second full paragraph under Roman two, Contention 2, which reads: "This presumably," and so forth, and end -- the second sentence, "I consider this position indefensible."

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Those two sentences will be stricken.

What's your next one?

MR. EDGAR: Page 7, the second full paragraph on the page, and the continuation over through the top of Page 8. The same grounds.

MS. FINAMORE: May I take a moment to read that?

JUDGE MILLER: Yes.

(Pause.)

MS. FINAMORE: I believe this particular paragraph is directly based on the extensive experience to which you referred earlier, that Dr. Morgan possesses.

He's talking about a source term which results in plutonium -- or can result in plutonium exposure to the public.

He has a great deal of experience -- I don't know too many people who have more --

JUDGE MILLER: What about experience with CDAs as credible accidents in this context?

MS. FINAMORE: Okay. I think what he's talking about is what the site suitability source term should be. And he is relating -- He has related his ideas on what the acceptable guidelines of those source terms should be, in order to prevent damage to the health and safety of the public.

14-7

I believe what he's saying here is that the Staff must prevent the kind of damage to the health and safety of the public to which he is referring by applying conservatisms at each step of its analysis.

Dr. Morgan is aware of how those conservatisms can, if added together at each step of the analysis, serve to meet the source term guidelines to which he is referring.

He's talking about the type of source term analysis that should be performed. That does not require an engineering judgment. That refers to a method of analysis with which he is intimately familiar.

I don't think that a degree in nuclear engineering at this point would be of any help in developing a source term analysis.

JUDGE MILLER: We're not talking about a degree. What we're talking about is an avowed area of expertise by an expert witness, who is undoubtedly expert in many respects, but the Board's problem is whether or not that expertise is sufficiently asserted by the witness and brought into play.

That's where our question is.

MS. FINAMORE: Well, he's not talking about what the design basis accident should be, which might require an engineering judgment here. He's talking about core disruptive accidents.

15-1
he

MS. FINAMORE: He's talking about how one should derive a source term analysis. He said one should apply conservatisms at each step of the process rather than best estimates.

I think he does have the requisite expertise to make a judgment as to whether one should apply conservatisms or best estimates in order to produce an adequate site suitability source term.

JUDGE MILLER: Well, the use of conservatisms, and the like, is the subject of many items of testimony by witnesses. It has much philosophical content. The question is not just the general proposition; the conservatisms, yes, but you don't just apply it automatically. The precise question is whether or not the conclusions which an expert witness can give, and which are therefore not objectionable upon the grounds of conclusory nature but they must rest upon a rational reason, integrated area of expertise which is relevant to the conclusions now.

MS. FINAMORE: Okay. I'd like to refer you to the final sentence on Page 8, and it's directly tied to the conclusion I just referred to. He's talking --

JUDGE MILLER: What's that, the "in particular, the Staff has recognized," and so forth?

MS. FINAMORE: Yes.

JUDGE MILLER: Well, let me just give you a

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little secret. We were about to let stand Page 7 but when we hit that part of Page 8, that tipped the balance against you. I'm sorry. We will strike it. The portion you picked is the one that tipped the balance the other way.

MS. FINAMORE: Well, let me refer to the portion on Page 7 then.

(Laugher.)

JUDGE MILLER: No, my next question about experts is are they sufficiently integrated that we must be consistent or can it be broken out? I am told, and they're my experts, I've got to rely on them, and I concur with them, we think it is interrelated to the extent that we should strike the part. If we feel that we should, it will have to go to the whole long paragraph. We will therefore strike, on Page 7, the last, or latter first full paragraph starting off "Regarding Intervenors' Contention 2(b), I agree," et cetera, continuing over on Page 8 to the end of that paragraph, which immediately precedes the letter B, and the Staff has not, and so forth. Okay. That will be stricken.

Now, what's the next --

MR. EDGAR: That's the end of my list.

JUDGE MILLER: All right. Does the Staff have anything now, above and beyond that we haven't ruled on, either expressly or implicitly?

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MR. SWANSON: Yes. If I may take the microphone, because the basis for this objection is the cross that I did of the Applicants' panel.

JUDGE MILLER: Which page, now, are you on?

MR. SWANSON: Okay. We're starting on Page 12. We're starting with the last paragraph, starting with Applicants have indicated, the rest of that page, all of Page 13, and the first full paragraph on Page 14.

The basis of this objection is that the testimony surrounds around an assumed composition of fuel described in the Table 3 on Page 13, plutonium after one four-year cycle, plutonium after two four-year cycles, plutonium recycle model BWR.

If you will -- if I could refer you to the transcript of my cross-examination of Applicants' panel, starting on page -- Transcript Page 1832 through 1834, it will indicate that I asked precisely the panel whether or not it is a description of the general size and type facility, whether or not their application contemplated fuel of that nature, and the answer in each case was no, that was not part of the application.

Their argument then, is this does not pertain to a general size and type facility as Clinch River.

MS. FINAMORE: May I respond to that one?

JUDGE MILLER: You may respond.

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MS. FINAMORE: First of all, Mr. Swanson is referring to statements made by the witnesses, to which we have not yet had an opportunity to rebut. I think it's, first of all, not appropriate at this time to strike portions of our testimony. If the Board finds that it agrees with one party and not with us, that's the Board's judgment to make.

JUDGE MILLER: Wait a minute. What is this rebuttal business? Why haven't you had an opportunity to rebut?

MS. FINAMORE: Well, excuse me, Judge Miller, from what I understood you saying this morning, and as the rules provide, we have an opportunity to rebut the evidence of the other parties.

JUDGE MILLER: I asked you who your witnesses were. Put on your rebuttal witnesses. We're closing this case out.

MS. FINAMORE: But Judge Miller --

JUDGE MILLER: Put them on if you claim a right to rebuttal.

MR. SWANSON: Mr. Chairman, if I could rephrase my argument, which avoids the term rebuttal in any sense, the party proposing the testimony has the burden of establishing a foundation of relevance for it, and the foundation is certainly not there.

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MS. FINAMORE: Okay. Judge Miller, aside from the question of rebuttal, which I believe you said this morning we would be able to provide in writing if we put our person on the stand, I'd just like to respond more directly to Mr. Swanson's case. We're referring --

JUDGE MILLER: Well, wait a minute. Let's not get the record mixed up. When I was talking about that, that was under the assumption we would not finish the panel in time to conclude the case today. The obvious answer is that the panel is through. We're ready. If you've got any rebuttal, bring them on. We're concluding this case because we were able, because of the time.

Now, when we talk about your ability to do something in the future, that is only if you don't have a present ongoing opportunity. You now have a present ongoing opportunity to cover everything; objections, rulings on objections, exhibits, rebuttal, everything except your motion, which we did and expressly reserved out for future consideration, and that only.

However, I'm told and I believe that the Staff is probably right, this being affirmative testimony it is requisite that an appropriate foundation of proof be made, and --

MS. FINAMORE: Okay. I will attempt to make that.

JUDGE MILLER: -- they're pointing out where

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there's a serious question about that, but we will be glad to hear from you.

MS. FINAMORE: I most certainly will.

JUDGE MILLER: Okay.

MS. FINAMORE: The Staff says that one of their Applicants stated that the application for a license contains a particular isotopic content requirement. I believe, correct me if I'm wrong, that the witness stated that it's also possible to amend such a license. If it's not true that the witness stated that, I think that the judges can take official notice that at any time an amendment can be licensed to allow a different isotopic content of --

JUDGE MILLER: Well, let me be truthful, we're not trying --

MS. FINAMORE: -- the fuel. May I complete my sentence?

JUDGE MILLER: No. Let me direct your attention now if you're going point by point.

The focus of our hearing here on the issues is not what might be done by amendment in the future. We're going on the existing and preceding. We've let you go into matters of the application that were to your benefit, as a matter of fact, but we let that go, but that did not mean that we're going to go into the possibility of a future

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application to do so and so. That's getting entirely too tenuous. So to the extent that you're argument is based on that, we want to indicate to you how we view it, but you probably have more grounds which we want to hear.

MS. FINAMORE: Okay. We certainly do.

Number one, if I'm correct, the scope of this hearing applies to a reactor of the general size and type as the CRBR.

JUDGE MILLER: Correct.

MS. FINAMORE: And that we were to focus on a reactor of a general size and type in a general way rather than on the specifics of the Clinch River Breeder Reactor.

JUDGE MILLER: As such, yes.

MS. FINAMORE: As such.

JUDGE MILLER: Or in detail, yes, you're correct.

MS. FINAMORE: Or in detail.

JUDGE MILLER: You're correct.

MS. FINAMORE: I would argume that that is one of the details that might not be applied to another reactor of the general size and type as the Clinch River, and in particular I might turn you to Page 14 of our --

JUDGE MILLER: 14. Okay.

MS. FINAMORE: -- of Dr. Morgan's testimony and --

JUDGE MILLER: Oh, okay.

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MR. FINAMORE: -- and specifically to the Applicants' document entitled "The Programmatic Environmental Impact Statement."

That is the basis for our argument here, and the basis is this. The programmatic impact statement discusses the Clinch River Breeder Reactor and other reactors as well that might be considered of the general size and type. As part of that program the Applicants have stated that they intend to construct a developmental reprocessing plant for purposes of reprocessing and recycling CRBRP fuel.

It is our argument, and again we're just introducing this as evidence, we're not asking the Board to rule on the merits of the argument right now, but simply on its relevance. We believe that this argument is a relevant one for a simple fact of logic, and the simple fact of logic is this. The only reason for including this statement, and for including a reprocessing plant in a breeder reactor program, is if one were to use the product of that reprocessing plant, which is simply reprocessed CRBRP fuel.

Given that, the only place that the reprocessed fuel could be used is in either the Clinch River Reactor itself or in a reactor of the general size and type as the Clinch River. That is the fact upon which we are

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relying. We feel that in this general kind of discussion at this point, when you are considering whether the site is suitable for a reactor of the general size and type as the CRBR, one should consider the fact -- and we're not asking for a ruling on the merits now, but this is a relevant piece of information that there will be available, and part of the program is to make available, fuel that is recycled, and that would very possibly contain a very different isotopic content.

I feel that's a very relevant piece of information here, especially since it is the Applicants' own information.

JUDGE MILLER: All right. The objection will be overruled. It may stand.

Now, is there anything else we haven't ruled on?

MR. EDGAR: Yes. I'd like to offer Applicants' Exhibit 33 into evidence. It is the ACRS letter.

JUDGE MILLER: Have the Intervenors introduced all of their exhibits? I'm not sure that you have.

MS. FINAMORE: No, there is still Exhibits 1 and 2. Let me --

JUDGE MILLER: Is that testimony? What is 1 and 2?

MS. FINAMORE: Well, let me finish the testimony. I introduced -- I move that Exhibits 4, 8 and 9 be introduced

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into evidence. Those are the testimonies of the three witnesses.

JUDGE MILLER: I thought we had ruled on those.

MS. FINAMORE: Did you rule on all of them?

JUDGE MILLER: Well, perhaps not. We have been considering the objections, and so except for those portions which have been stricken, those exhibits -- what are their numbers again?

MS. FINAMORE: 4, 8 and 9.

JUDGE MILLER: 4, 8 and 9 are admitted, subject only to the portions that the Board has stricken.

MS. FINAMORE: That's correct.

JUDGE MILLER: Okay.

(The documents referred to, heretofore marked for identification as Intervenors' Exhibits Nos. 4, 8 and 9 were received in evidence and is hereby incorporated into the record.)

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BEFORE THE
UNITED STATES NUCLEAR REGULATORY COMMISSION
ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	
U.S. DEPARTMENT OF ENERGY PROJECT MANAGEMENT CORPORATION TENNESSEE VALLEY AUTHORITY	Docket No. 50-537
(Clinch River Breeder Reactor	

TESTIMONY OF THOMAS B. COCHRAN

Part II

Introduction

I will now discuss Intervenors' Contentions 2 and 3(c), which both relate to the site suitability analysis under 10 CFR 100. Contention 2 is as follows:

> The analyses of CDAs and their consequences by Applicants and Staff are inadequate for purposes of licensing the CRBR, performing the NEPA cost/benefit analysis, or demonstrating that the radiological source term for CRBRP would result in potential hazards not exceeded by those from any accident considered credible, as required by 10 CFR §100.11(a), fn. 1.
>
> (a) The radiological source term analysis used in CRBRP site suitability should be derived through a mechanistic analysis. Neither Applicants nor Staff have based the radiological source term on such an analysis.

(b) The radiological source term analysis should be based on the assumption that CDAs (failure to scram with substantial core disruption) are credible accidents within the DBA envelope, should place an upper bound on the explosive potential of a CDA, and should then derive a conservative estimate of the fission product release from such an accident. Neither Applicants nor Staff have performed such an analysis.

(c) The radiological source term analysis has not adequately considered either the release of fission products and core materials, e.g. halogens, iodine and plutonium, or the environmental conditions in the reactor containment building created by the release of substantial quantities of sodium. Neither Applicants nor Staff have established the maximum credible sodium release following a CDA or included the environmental conditions caused by such a sodium release as part of the radiological source term pathway analysis.

(d) Neither Applicants nor Staff have demonstrated that the design of the containment is adequate to reduce calculated offsite doses to an acceptable level.

(e) As set forth in Contention 11(d), neither Applicants nor Staff have adequately calculated the guideline values for radiation doses from postulated CRBRP releases.

[Contention 11(d) states:

[Guideline values for permissible organ doses used by Applicants and Staff have not been shown to have a valid basis.

[(1) The approach utilized by Applicants and Staff in establishing 10 CFR § 100.11 organ dose equivalent limits corresponding to a whole body dose of 25 rems is inappropriate because it fails to consider important organs, e.g. the liver, and because it fails to consider new knowledge, e.g., recommendations of the ICRP in Reports 26 and 30.

[(2) Neither Applicants nor Staff have given adequate consideration to the plutonium "hot particle" hypothesis advanced by Arthur R. Tamplin and Thomas B. Cochran, or to the Karl Z. Morgan hypothesis described in "Suggested Reduction of Permissible Exposure to Plutonium and Other Transuranium Elements," Journal of American Industrial Hygiene (August 1975).]

(f) Applicants have not established that the computer models (including computer codes) referenced in Applicants' CDA safety analysis reports, including the PSAR, and referenced in the Staff CDA safety analyses are valid. The models and computer codes used in the PSAR and the Staff safety analyses of CDAs and their consequences have not been adequately documented, verified or validated by comparison with applicable experimental data. Applicants' and Staff's safety analyses do not establish that the models accurately represent the physical phenomena and principles which control the response of CRBR to CDAs.

(g) Neither Applicants nor Staff have established that the input data and assumptions for the computer models and codes are adequately documented or verified.

(h) Since neither Applicants nor Staff have established that the models, computer codes, input data and assumptions are adequately documented, verified and validated, they have also been unable to establish the energetics of a CDA and thus have also not established the adequacy of the containment of the source term for post accident radiological analysis.

Contention 3(c), which relates to Contention 2(c), is as follows:

c) Accidents associated with core meltthrough following loss of core geometry and sodium-concrete interactions have not been adequately analyzed.

These contentions assert the failure of the Applicants and the Staff to comply with the requirements of 10 CFR Part 100, the Commission's Reactor Site Criteria, particularly Section 100.11[1]. We will defer to the second phase of these hearings

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[1] Section 100.11 states:

> As an aid in evaluating a proposed site, an applicant should assume a fission produce release1/ from the core, the expected demonstrable leak rate from the containment and the meteorological conditions pertinent to his site to derive an exclusion area, a low population zone and population center distance. For the purpose of this analysis, which shall set forth the basis for the numerical values used, the applicant should determine the following:
>
> (1) An exclusion area of such size that an individual located at any point on its boundary for two hours immediately following onset of the postulated fission product release would not receive a total radiation dose to the whole body in excess of 25 rem2/ or a total radiation dose in excess of 300 rem2/ to the thyroid from iodine exposure.
>
> (2) A low population zone of such size that an individual located at any point on its outer boundary who is exposed to the radioactive cloud resulting from the postulated fission product release (during the entire period of its passage) would not receive a total radiation dose to the whole body in excess of 25 rem or a total radiation dose in excess of 300 rem to the thyroid from iodine exposure.
>
> (3) A population center distance of at least one and one-third times the distance from the reactor to the outer boundary of the low population zone. In applying this guide, the boundary of the population center shall be determined upon consideration of population distribution. Political boundaries are not controlling in the application of this guide. Where very large

(continued on next page)

these hearings the question of whether the analysis of CDAs and their consequences are adequate for performing the NEPA cost/benefit analysis, although much of my testimony is relevant to the findings the Board must make under both Part 100 and Part 51.

(footnote 1 continued)

cities are involved, a greater distance may be necessary because of total integrated population dose consideration.

1/ The fission product release assumed for these calculations should be based upon a major accident, hypothesized for purposes of site analysis or postulated from considerations of possible accidental events, that would result in potential hazards not exceeded by those from any accident considered credible. Such accidents have generally been assumed to result in substantial meltdown of the core with subsequent release of appreciable quantities of fission products.

2/ The whole body dose of 25 rem referred to above corresponds numerically to the once in a lifetime accidental or emergency dose for radiation workers which, according to NCRP recommendations may be disregarded in the determination of their radiation exposure status (see NBS Handbook 69 dated June 5, 1959). However, neither its use nor that of the 300 rem value for thyroid exposure as set forth in these site criteria guides are intended to imply that these numbers constitute acceptable limits for emergency doses to the public under accident conditions. Rather, this 25 rem whole body value and the 300 rem thyroid value have been set forth in these guides as reference values, which can be used in the evaluation of reactor sites with respect to potential reactor accidents of exceedingly low probability of occurrence, and low risk of public exposure to radiation.

In the testimony that follows, I intend to show that:

I. The assumed fission product release in the site suitability source term chosen by the Staff is not sufficiently conservative;

II. The Staff's proposed source term does not include the pressure and thermal effects associated with core meltthrough, and is therefore nonconservative;

III. The Staff has not correctly performed or adequately documented the dose calculations in the source term analysis and has failed to select conservative 10 CFR Part 100 guidelines for internal organs;

IV. Neither Applicants nor Staff have established that the models, computer codes, input data and assumptions used to determine the suitability of the CRBR site are valid.

I. The Assumed Fission Product Release in the Site Suitability Source Term Chosen By the Staff is Not Sufficiently Conservative.

Intervenors' first argument under Contention 2 is that the assumed fission product release in the site suitability source term chosen by the Staff as an aid in evaluating the proposed site is not sufficiently conservative to meet the Commission's intent and requirements under the 10 CFR Part 100 Reactor Siting Criteria. To understand why this is so, it is helpful to begin with a discussion of the policy underlying Part 100 and the meaning of its requirements.

A. History of 10 CFR Part 100

The 10 CFR Part 100 Reactor Site Criteria were promulgated in 1962 after extensive public comment by the NRC's predecessor, the Atomic Energy Commission (the "AEC"). 27 Fed. Reg. 3509 (1962). It can readily be seen that these site suitability requirements were intended to provide a substantial additional layer of conservatism above and beyond that provided by safety features designed to mitigate against design basis accidents. In other words, the AEC decided that, even if the plant were designed to prevent and mitigate against all credible accidents, the possibility for a much more serious, though highly improbable, accident could never be completely discounted, and therefore its consequences must be considered when siting the plant. Atomic Energy Commission Reactor Site Criteria, Report to the Director of Regulation by the Director, Licensing and Regulation, AEC-R 2/39, Appendix D at p. 9. As stated in the Notice of Proposed Guides:

> The basic objectives which it is believed can be achieved under the criteria set forth in the proposed guides, are:
> a) Serious injury to individuals offsite should be avoided if an unlikely, but still credible, accident should occur.
> b) Even if a more serious accident (not normally considered credible) should occur, the number of people killed should not be catastrophic.

26 Fed. Reg. 1224 (Feb. 11, 1961).[2] The regulations state that the major accident from which the source term should be calculated has "generally been assumed to result in substantial meltdown of the core with subsequent release of appreciable quantities of fission products." 10 CFR §100.11(a), n. 1.

The site suitability source term for light water reactors, which was developed after many years of licensing and operating experience, was based upon a step-by-step analysis of a major postulated accident, one with consequences far exceeding those of any LWR design basis accident. The source term was derived using highly conservative assumptions, and is based upon a series of highly unlikely events occurring in sequence. First, the analysis postulated that the coolant piping ruptures completely from high internal pressures due to uncontrolled internal heat generation, which in turn could only occur if:

(1) Reactivity control mechanisms fail to function,

(2) High pressure relief systems fail to perform, and

(3) Pressures exceed rupture limits of the piping material.

Furthermore, in order to postulate that this complete shear of a coolant pipe, itself an extremely unlikely event, would result in fuel melting, the analysis also assumes that:

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[2] These objectives were eliminated from the final rulemaking notice, "since it is believed that they have already served their purpose and need no reiteration in any subsequent publication in the Register." AEC-R 2/39, supra p. 7, at Appendix B, p. 7.

(1) Decay heat is sufficient to increase fuel temperature to the melting point; and

(2) Safeguards systems provided to flood or spray the core with water are either inoperative or insufficient to keep fuel temperatures from rising.

Atomic Energy Commission Reactor Site Criteria, Report to the General Manager by the Director, Division of Licensing and Regulation, AEC-R 2/19, Appendix B at 21-22. This accident is not just incrementally larger than the limiting design basis accident for light water reactors; it is orders of magnitude larger. This difference reflects the substantial conservatism utilized in the site suitability analysis to provide a second level of defense.[3] When combined with the

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[3] Additional conservatisms were built in to determine the extent of the fission product release from this accident, and the amount released to the environment:

(1) It is assumed that the reactor is a pressurized water type for which the maximum credible accident will release into the reactor building 100 percent of the noble gases, 50 percent of the halogens and 1 percent of the solids in the fission product inventory. Such a release represents approximately 15 percent of the gross fission product activity.

(2) Fifty percent of the iodines in the containment vessel is assumed to remain available for release to the atmosphere. The remaining fifty percent of the iodines is assumed to absorb onto internal surfaces of the reactor building or adhere to internal components. Rather than the assumed reduction factor of two, it is estimated that removal of airborne iodines by various physical phenomena such as adsorption, adherence and settling could

(continued on next page)

conservatisms applied to calculations of the extent of the fission product release to the environment and off-site doses, the Commission concluded that "the net effect of the assumptions and approximations is believed to give more conservative results (greater distances) than would be the case if more accurate calculations could be made." AEC-R 2/39, supra p. 7, Appendix D at 13.

While the Commission believed this approach to be appropriate for LWRs as "represent[ing] the same very conservative approach to site selection that has characterized

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(footnote 3 continued)

> give an effect of 3-10 reduction in the final result. Credit has not been taken for the effects of washdown or filtering from protective safeguards such as cooling sprays and internal air recirculating systems. Washdown features and filtering networks could provide additional reduction factors of 10-1000.
>
> (3) The release of available (airborne) radioactivity from the reactor building to the environment is assumed to occur at a constant leakage rate of 0.1 per cent per day. The leakage and pressure conditions are assumed to persist throughout the effective course of the accident, which for practical purposes, would be until the iodine activity becomes insignificant. The maximum pressure within the reactor building and the leakage rate would actually decrease with time as the steam condenses from contact with cooling surfaces. By assuming no change in leak rate as a function of pressure drop, it is estimated that the final off-site doses calculated may be too high by factors of 5-10.

AEC-R 2/39, supra p. 7, Appendix D at 14-15 .

such evaluations in the past," id., it explictly recognized that even more conservatism is required in siting reactor types with no previous licensing experience:

> The site criteria contained in this part apply primarily to reactors of a general type and design on which experience has been developed, but can also be applied to other reactor types. In particular, for reactors that are novel in design and unproven as prototypes or pilot plants, it is expected that these basic criteria will be applied in a manner that takes into account the lack of experience. In the application of these criteria which are deliberately flexible, the safeguards provided--either site isolation or engineered features--should reflect the lack of certainty that only experience can provide.

10 CFR §100.2(b) (emphasis added).

In any site suitability analysis, the Commission envisioned that an applicant could trade off the use of engineered safeguards for site isolation only when the safeguards were "extensive and well proven," Atomic Energy Commission, Reactor Site Criteria - Draft Regulations Submitted to ACRS, AEC-R 2/22, Dec. 10, 1960, at 2, based on operating experience from plants already licensed. AEC-R 2/39, supra p. 7, Appendix B at 7. The agency believed such licensing experience was essential "to provide a more definitive basis for weighing the effectiveness of engineered safeguards versus plant isolation as a public safeguard." Id. The Advisory Committee on Reactor Safeguards (the "ACRS") firmly believed that novel or unproven reactor types, which necessarily lacked previous licensing

experience, "belong at isolated sites -- the degree of isolation required depending on the amount of experience which exists." AEC-R 2/39, supra p. 7, Appendix C-2 at 2.

B. The Assumed CRBR Site Suitability Fission Product Release Is Insufficiently Conservative Whether or Not Core Disruptive Accidents are Considered Credible Accidents Within the Design Basis

The assumed fission product release, or source term, chosen by the Staff for the CRBR site suitability analysis is set forth in the 1982 SSR at III-11. The Staff claims that the source term is non-mechanistic, and is directly analogous to the LWR source term, modified only to include the release of 1% of the plutonium fuel from the core, (a value that is identical to and derived from the percentage of nonvolatile fission products in the LWR source term). 1982 SSR at II-8 - II-9. The Staff also claims that the source term is based on a CDA in which ten percent of the core is vaporized, and ten percent of that vapor escapes from the vessel head into the containment, resulting in a total plutonium release of one percent. Transcript of Advisory Committee on Reactor Safeguards CRBR Subcommittee Meeting, June 24, 1982 at pp. 165, 169-70. The Staff's proposed source term is insufficiently conservative, regardless of its derivation, and whether or not core disruptive accidents are considered to be credible

accidents within the design basis of the CRBR. If, as I firmly believe, CDAs are credible accidents, then the Staff's source term clearly does not bound the consequences of a major CDA. This is evident from the fact that when the Staff derived a site suitability source term for Applicants' Parallel Design, in which a CDA is considered a credible accident within the design basis, the assumed fission product release included ten percent of the plutonium fuel:

Proposed Staff Source Term for Parallel Design

Noble Gas	(%)	100
Halogens	(%)	100
Volatiles	(%)	100
Solid F. P.	(%)	10
Fuel (Inc.Pu)	(%)	10
Sodium	(lb)	1000 (Spray)

Letter dated Feb. 2, 1976, from Van Nort to Boyd, "Clinch River Breeder Reactor Plant Project - Project Office Summary of January 22, 1976 Meeting on Site Suitability Source Term," at 5.

Even larger site suitability source terms have been used in the past to bound core disruptive accidents in other reactors.

For example, in EBR-II, the source term assumed that 50% of the fission product activity contained in the reactor (and 50% of the Pu-239) is released to the atmosphere from the hypothesized reactor disaster. Argonne National Laboratory, Hazard Summary Report, Experimental Breeder Reactor II (EBR-II), May, 1957, at Appendix F, p. 343. And in SEFOR it was assumed that, as a result of a core disruptive design basis accident, the entire core is volatized with 100% of the available fission products and 100% of the plutonium released into the inner containment space. Safety Evaluation By the Division of Reactor Licensing, U.S. Atomic Energy Commission, In the Matter of Southwest Experimental Fast Oxide Reactor, Nov. 18, 1968, at 27.[4]

The Staff has not done the necessary analysis to determine whether the currently proposed source term would sufficiently bound all credible CDAs, let alone perform the necessary mechanistic analysis with built-in conservatisms at every step. The Staff admits that its assumption that ten percent of the plutonium from the core is vaporized is based upon no

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[4] The site suitability source term for the FFTF, which was constructed by the Applicant, Department of Energy, contained the same fuel fraction release as that proposed for the CRBR; i.e., one percent plutonium. Yet since this facility was never licensed by the NRC, there was no mechanism by which Intervenors or others could challenge the validity of this source term, and consequently one should not attach undue weight to its estimates.

estimation of how many fuel assemblies would fail,[5] and does not consider the specific component designs proposed by the applicants.[6] The Staff has supplied no analyses of the potential consequences of various core disruptive accidents, and in fact considers such analyses to be beyond the scope of this proceeding. Letter from Daniel T. Swanson to Administrative Judges dated April 16, 1982 at 2. In fact, the Staff admits that it would have to redo its analysis of the source term if CDAs were considered credible, since the Staff has no idea whatsoever if its assumptions would remain conservative:

> Mr. Cochran: Then the conservatism with regard to the source term is dependent on a conclusion that CDAs are not credible events?
>
> Mr. Morris: Yes. However, it is not beyond the possibility that if CDAs were considered credible, that the source term could still be found to be conservative.
>
> Mr. Cochran: You don't know about it because you have not done the analysis?
>
> Mr. Morris: That is right.
>
> . . . .

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5 Transcript of Deposition by Intervenors of William Morris, Richard Stark, Wayne Houston, and Paul Leech, May 6, 1982 [hereinafter Deposition of NRC Staff], at p. 178 (statement of Mr. Hulman).

6 Id., at pp. 42-43 (statement of William Morris).

> Mr. Cochran: Setting aside how it was derived, is the source term conservative when compared to the maximum theoretical work energy that might be produced in a CDA at the CRBR?
>
> Mr. Houston: I don't know whether anyone has ever made that comparison.
>
> Mr. Cochran: Would it be conservative with respect to the probable energy release of a CDA in the CRBR?
>
> Mr. Houston: I don't know.

Deposition of NRC Staff at pp. 152, 178.

Nor have the Applicants performed the necessary analysis of whether the Staff's source term is sufficiently bounding if CDAs were considered credible:

> Mr. Cochran: Has the project considered what the consequences would be to the design and siting of the Clinch River Breeder Reactor if the CDA were within the design basis accident spectrum?
>
> Witness Clare: I am not aware of any analysis that is, that comprehensively considers a hypothetical core disruptive accident as the design basis in terms of its overall impact on the design and the siting.
>
> Mr. Cochran: You are the project's expert in this area, are you not?
>
> Witness Clare: I am an expert in this area.
>
> . . . .
>
> Mr. Cochran: Are any of you aware whether the project has considered what the consequences would be to the design and siting of the Clinch River Breeder Reactor if the CDA were within the design basis accident spectrum?

> Witness Brown: I think that in the context, in a limited context the parallel design represented a project consideration, but I don't -- it was not the total implication. It wasn't a separate study that focused just on that total aspect of it, but it was a consideration of some of the implications of what taking an HCDA as a design basis accident --
>
> . . . .
>
> Mr. Cochran: And is it also correct that there is a spectrum of CDAs for which that design and those design parameters or site suitability source term analysis parameters would not be correct?
>
> Witness Clare: One can hypothesize HCDAs in the CRBRP where these leak rates would not apply.
> Mr. Cochran: In general, wouldn't those type of CDAs be associated with large sodium releases, for example, to the reactor cavity?
>
> Witness Clare: Some of those scenarios would include that, yes.
>
> . . . .
>
> Mr. Cochran: If the CDA were a design basis accident, is it possible that that source term would have to be revised?
>
> Witness Clare: You are postulating a different situation than that, which leads us to our current design in the hypothetical sense that you are raising. Where the design basis accidents change, one would have to reconsider the design of the plant and the site suitability source term.

Transcript of Deposition by Intervenors of George H. Clare, Neil W. Brown, and L. Walter Deitrich, June 16, 1982, at pp. 143-144, 150, 152-153.

According to the statements of the Staff and the Applicants, therefore, if it is proven than CDAs are credible

accidents that should be within the CRBR design basis, then both the Staff and the Applicants will have to redo their source term analysis, something neither has yet done, to determine whether and how the source term should be revised. Evidence from the treatment of other reactors, and from the Staff's own preliminary analysis of the Parallel design, indicates that the assumed plutonium release from the core would have to be increased by at least a factor of 10.[7]

Even if this Board finds that core disruptive accidents are incredible and outside the design basis accident envelope, I believe that the Staff's proposed source term is still inadequately conservative for several reasons. First, as stated above, the Staff may not treat this first-of-a-kind reactor as it would a tested, proven light water reactor design. 10 CFR §100.2(b). Instead, it must apply additional conservatisms to take into account the utter lack of breeder reactor licensing experience. The Staff must factor in these conservatisms either by selecting a more isolated site than it would for a tested design or by requiring extensive and well-proven engineered safeguards. It is not enough for the

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[7] Even the Applicants admit that treating the CDA as a credible design basis would increase the plutonium release fraction by a factor of 10. See the Applicants' assumed source term for the Reference and Parallel designs in PSAR, 15.A-10; PSAR Amend. 3 Aug. 1975, 15.A-4.

Staff to extrapolate directly from the LWR source term without substantial additional margins of safety to account for the uncertainties inherent in this novel design. Nor is it enough for the Staff or the Applicants to point to engineered safeguards which have not been proven or previously licensed and, indeed, which will not even be fully scrutinized until a later licensing stage. Unless the Staff increases the source term by some additional margin to take account of the novel, untested nature of the CRBR, it violates both the requirements and the intent of 10 CFR Part 100.

Second, because breeder reactors such as the CRBR have an accident potential far greater than that of any conventional reactor, and because the parties lack all but the most preliminary information on CRBR safety at this early licensing stage, the source term chosen now must be large enough to bound any accidents which the Staff may later determine to be credible after a full safety review. As the NRC Staff cautioned the Applicants in 1976:

> If the intent of the project is to proceed through the licensing process in an expeditious manner, then it is our opinion that the design approach must be of an enveloping nature and sufficiently conservative to account for further design modifications and uncertainties.

Letter, dated April 23, 1976, from Themis P. Speis, Chief of the NRC Liquid Metal Fast Breeder Reactor Branch, to Peter S.

Van Nort, Project Management Corporation General Manager (emphasis added).

The Atomic Energy Commission recognized the need for additional conservatisms in situations like these when

> [t]he necessity for site appraisal arises early in the life of a project when many of the detailed features of design which might affect the accident potential of a reactor are not settled[;]

and recognized "the inherent difficulty of postulating an accident representing a reasonable upper limit of potential hazard." AEC-R 2/39, supra p. 7, Appendix D at p. 7. In this case, the greater-than-usual accident potential of the plant and the earlier-than-usual site review mandates that the Staff ensure that its source term is sufficiently conservative to envelope the substantial uncertainties that exist. The Staff took this approach elsewhere in the siting analysis by lowering the organ dose guideline values by a factor of 10 (now 2) during the construction permit and LWA review stages from those values applied during the operating license stage. In applying this principle here, the Staff should increase its plutonium release fraction by a factor of at least 10 to account for the substantial possibility that CDAs will be found credible after a full safety review.

The Applicants may argue that, since the extensive work that would be performed under a limited work authorization is at their own risk, neither the Staff nor the Board need be

concerned that LWA-1 site evaluations retain their validity at a later licensing stage. Such an approach would render this hearing superfluous and make a mockery of the siting process. It also ignores the substantial interest of the people living near the proposed site and the public at large, who are financing this project, in ensuring that money is not wasted and the land needlessly leveled because of a peremptory decision at this stage that later proves mistaken.Moreover, the claim that Applicants proceed at their "own" risk is substantially undercut by NRC precedent indicating that the money and time spent at this site will be accounted against alternative sites.

Finally, I believe that, when compared with the LWR source term, the proposed CRBR source term provides nowhere near the amount of conservatism necessary, even if CDAs are not considered credible or design basis accidents. The proper inquiry is not only whether the source term bounds all design basis accidents, but also the extent to which the accident is bounding. If the Commission intended to require only that the source term bound all design basis accidents, then the LWR source term would not have been orders of magnitude greater than the largest LWR design basis accident. An approach similar to that used in light water reactors is necessary to achieve Part 100's objective of providing against excessive exposure doses from conceivable though highly improbable

accidents. 27 Fed. Reg. 3509 (Apr. 1962). As I have indicated in my testimony on Contention 1, the maximum capacity for harm from an LMFBR accident has been estimated to be an order of magnitude greater than that from an LWR. This difference is not reflected in the Staff's choice of the source term, namely the LWR souce term plus 1% of the plutonium.

Various analyses of CDAs have postulated the releases of up to 10 percent of the plutonium from the core. See CRBRP-3, Vol. 2, at p. 4-17 (assumes 5% plutonium release); CRBRP-1 at p. 7-13 (assumes 10% plutonium release from the core to the environment from a highly energetic accident that is postulated to fail the primary coolant boundary and penetrate the outer containment). I believe a fuel release fraction of 10% plutonium, or a factor of two higher to provide an additional safety margin in recognition of the fact that the upper bound of the CRBR explosive potential has not been defined, would be an appropriate source term even if core disruptive accidents are not within the design basis envelope.

II. The Staff's Proposed Source Term Does Not Include the Pressure and Thermal Effects Associated With Core Meltthrough, and is Therefore Nonconservative

Intervenors' second challenge to the Staff's proposed CRBR source term is that it does not include the pressure and

thermal effects associated with core meltthrough, and is therefore nonconservative.[8] The reasons why such effects must be considered are as follow:

The Staff's proposed source term is apparently premised on the occurrence of a core disruptive accident. See Transcript of ACRS CRBR Subcommittee Meeting, July 24, 1982, at p. 178. In a site suitability analysis one should conservatively assume, as Applicants have done, that all accident sequences leading to a CDA would lead to whole core involvement. See CRBRP-1 at p. 3-17. One should also conservatively assume that

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[8] The Staff admitted that it did not consider these effects in its source term analysis:

> The source term is postulated to enter containment and then to have no associated effects on the possibility of sodium being the source of sodium fire in containment. Sodium-concrete interactions causing an overpressurization of containment and all that would have to go along with any mechanistic scenario of a core disruptive accident.
>
> That is where -- that is where this attempt should take place -- non-mechanistic source term -- and try to relate it to a mechanistic accident really fails. The treatment of the site suitability source term does not assume, for instance, an overpressurization of containment beyond design pressure.

Transcript of ACRS CRBR Subcommittee Meeting, July 24, 1982, at p. 171 (statement of William Morris).(continued on next page)

the molten fuel will penetrate through the bottom of the reactor vessel and guard vessel. Id. at 4-7. Such a core melt event was the basis for the NRC Staff's radiological site suitability source term analysis for the FFTF. U.S. Nuclear Regulatory Commission, Safety Evaluation Report related to operation of Fast Flux Test Facility, Department of Energy, Aug. 1978, at pp. 15-58 - 15-65.

Once meltthrough of the core vessel and guard vessel occurs, approximately 1000 seconds into the accident (see CRBRP-3, Vol. 2 at p. 3-18), all of the available sodium in the reactor vessel and primary loops, i.e., approximately 1.1 million pounds, would very likely be dumped into the reactor cavity. See CRBRP-1 at p. 7-7; CRBRP-3, Vol. 2 at p. 3-19. In addition, for an energetic CDA, a small fraction of the sodium in the reactor vessel would be expected to follow the path of the fuel release through the head seals into the secondary containment. The sodium released from the reactor vessel would be expected to result in sodium fires and interactions with the concrete in the reactor cavity, resulting in overpressurization and high thermal loadings of the secondary containment. Applicants' predicted progression of a core melt scenario includes these events, and is generally described in CRBRP-3, Vol. 2, at pp. 3-18 - 3-26.[9]

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[9] Intervenors do not necessarily endorse all the quantitative values set forth in this core melt scenario.

Since the Staff's CRBR site suitability source term analysis is based upon a CDA, it cannot simply ignore the pressure and thermal loading implications of such an event. To do so would be to negate whatever conservatisms otherwise exist in the analysis. Indeed, the FFTF site suitability analysis did consider these pressure and thermal loading effects, and included the possible effects of venting. FFTF Safety Evaluation Report, supra at 15-58 - 15-65.

The Staff's site suitability source term analysis with regard to the containment evaluation not only ignores the effects of overpressurization and thermal loading in the containment, but also incorrectly models the actual containment that is being proposed. The Staff's source term analysis, unlike that of the FFTF, assumes that radiological releases to the environment, even from the most severe accident, will only occur via annulus filtration and bypass leakage of 0.001% per day. 1982 SSR at p. III-11. Yet the Applicants have proposed a system whereby, in the case of a CDA, [redacted] radioactivity in the containment would be released directly to the environment through filtered vents. CRBRP-3, Vol. 2, p. 2-7. And the Staff has elsewhere required that, following an accident, containment integrity need be maintained for only 24 hours before such venting is permitted. Letter dated May 6, 1976 from Richard P. Denise to Lochlin W. Caffey.[10] Under this

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[10] The Applicants' current provisions for venting are still under review by the Staff. 1982 SSR at pp. II-18 - II-19.

schizophrenic approach the Staff now assesses the suitability of the CRBR site based upon a containment design with no vents, but includes venting to accommodate a core disruptive accident, the very same accident from which the site suitability source term is derived. This approach means that the site suitability analysis is in fact less conservative than the accident analysis for the plant itself. Rather than provide a second level of defense, this site suitability analysis has become little more than a justification for the proposed site.

In summary, I believe my testimony indicates that the Staff's CRBR site suitabiity source term is inadequate because of its insufficiently conservative assumed fuel release fraction and its failure to consider the pressure and thermal effects associated with core meltthrough. Given either one of these inadequacies, and correcting for no other errors, it is obvious that the site is unsuitable for a reactor of the general size and type as the CRBR. But even assuming, for purposes of argument, that the proposed source term is appropriate, the site is still demonstrably unsuitable when certain other errors in the Staff's analysis are corrected.

III. Staff Has Not Correctly Performed or Adequately Documented the Dose Calculations in the Source Term Analysis and Has Failed to Select Conservative 10 CFR Part 100 Guidelines for Internal Organs

It is apparent from the 1982 SSR that the Staff has not correctly performed or adequately documented the dose calculations in the source term analysis and has failed to select conservative 10 CFR Part 100 guidelines for internal organs. Dr. Karl Z. Morgan, in his testimony earlier, outlined a number of errors in Staff's site suitability dose calculations, including:

a) failure to consider the dose "from the entire passage of the cloud;"

b) failure to use conservative values for the plutonium isotopic concentrations;

c) failure to consider all isotopes of interest;

d) failure to use current dosimetric and metabolic models;

e) failure to consider all pathways;

f) failure to properly calculate the bone (and bone surface) dose;

g) failure to document adequately the dose calculations assumptions and methodology.

Dr. Morgan also challenges the Staff's proposed 10 CFR Part 100 dose guidelines for lung and bone. Testimony of Dr. Karl Z. Morgan at pp. 8-24.

With regard to inadequacies in Staff's dosimetric and

metabolic modeling, and with regard to calculations of the internal organ doses, I fully subscribe to the views of Dr. Morgan as set forth in his testimony and incorporate his testimony by reference (pp. 8-20). With regard to 10 CFR 100 guideline values for internal organs, I subscribe to and incorporate by reference the views of Dr. Morgan (pp. 21-29) and the conclusions of Dr. John C. Cobb as set forth in their respective testimony. I also wish to elaborate further my own views on these matters.

A. The Proposed Dose Guideline Values for Lung and Bone Are Too High

The Staff has assumed dose guideline values of 75 rem to the lung and 300 rem to the bone surface. 1982 SSR at III-9. These values are reduced by a factor of 2, for purposes of review at the construction permit and LWA-1 stages, to values of 35 rem to the lung and 150 rem to the bone surface. Id. These values were derived from the stochastic weighting factors in ICRP 26. Id.; see also ICRP 26, para. (105). The first problem with these values is that the Staff has misapplied the ICRP 26 methodology by ignoring the additional limits on organ doses of 50 rem/per year to the lung and bone surface, recommended by ICRP 26 in order to prevent non-stochastic effects. ICRP 26, para.(103). The U.S. Environmental Protection Agency, in adopting the methodology of ICRP 26, recently proposed a dose commitment limit of 30 rem/per year

to these same organs to prevent non-stochastic effects. USEPA, Proposed Federal Radiation Guidance for Occupational Exposure, Background Report, EPA 520/4-81-003, Jan. 1981, at p. 10. While I will argue below in favor of even lower dose guideline values, at this point I simply wish to note that the 50 rem and 30 rem limits recommended by ICRP and EPA respectively are consistent with the original intent of the 10 CFR 100 Reactor Site Criteria, which was to ensure that "[s]erious injury to individuals offsite should be avoided if an unlikely, but still credible, accident should occur", 26 Fed. Reg. 1224 (Feb. 11, 1961), and the admonition of the ICRP that its recommended limits are necessary to prevent harmful non-stochastic effects. ICRP 26, para.(103).

It is worth noting that, when the ACRS first proposed site suitability guideline values, it selected 25 rems to the whole body, 300 rems to the thyroid, and 25 rems to the bone and lung. Atomic Energy Commission, ACRS Comments on Site Criteria for Nuclear Reactors, AEC-R 2/23, Dec. 13, 1960, at p. 3.[11] These proposed bone and lung limits are more compatible with the ICRP and EPA non-stochastic limits than the much higher guideline values proposed by the Staff.

I might also note that, under EPA's environmental radiation protection standards for normal operations of the uranium fuel cycle, the following annual dose equivalence limits to members

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[11] These bone and lung values were presumably dropped because they were not considered controlling for light water reactor accidents.

of the public are set forth: 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ, e.g., lung and bone surface. 40 CFR §190.10(a). Based on these regulations, the lung and bone surface doses equivalent to 25 rem to the whole body would be 25 rem to the lung and bone surface. Again, these limits are substantially lower than the limits proposed by the Staff, yet more consistent with the lung and bone surface limits recommended by EPA and ICRP 26, and the original proposed ACRS guidelines.

I believe that even smaller dose guideline values for lung and bone surfaces than those of ICRP and EPA to limit non-stochastic effects are necessary for the following reasons. First, I wholly subscribe to the views of Dr. Morgan that the lung and bone surface guidelines should not exceed the EPA proposed guidance on dose limits for persons exposed to transuranium elements in the general environment; namely, 1 mrad per year to the lung and 3 mrad per year to the bone. Karl Z. Morgan Testimony at p. 21. Second, I agree with Dr. Morgan's conclusion that the Staff's proposed dose levels of 150 rem to the bone and 35 rem to the lung "would result in severely serious consequences and are far beyond acceptable levels." Karl Z. Morgan Testimony at p. 24. Third, as noted previously, I endorse fully the statements of Dr. Morgan and Dr. Cobb that the factor of 2 reduction in bone surface and lung dose guidelines at the construction permit and LWA-1 stage to account for uncertainties is far too small. I will discuss this point in the next portion of my testimony.

B. The Factor of 2 Reduction Used to Lower the Lung and Bone Dose Guidelines at the CP and LWA Stages Does Not Sufficiently Account for Uncertainties in Dose Models And Radiological Risks

In the 1977 SSR, the Staff used a factor of 10 to reduce the dose guidelines for the lung and bone dose at the CP and LWA stages. This factor of 10 was the product of two factors:

> 1) a factor of about 2 to take into account uncertainties in final design detail and meteorology and new data and calculational techniques that might influence the final design of engineered safety features or the dose reduction factors allowed for those features; and
> 2) a conservative factor of 5 to take into account uncertainties in dose and health effect models.

In the 1982 SSR (p. III-9), the Staff reduced this uncertainty factor from 10 to 2, claiming that the factor of 5 to take into account uncertainties in dose and health effects models is no longer needed .[12] This claim is totally unsupportable.

The adequacy of the current Federal radiation protection standards for plutonium and other transuranic elements has been a matter of considerable debate for a number of years. One, but by no means the only, issue has been the adequacy of these standards to account for the fact that when alpha-emitting radionuclides are deposited in human tissue as particulates, or

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[12] NRC Staff's Supplement Answers to Natural Resources Defense Council, Inc. and the Sierra Club Twenty-Sixth Set of Interrogatories to Staff, at pp. 19-20.

otherwise accumulate in high concentrations, e.g. in the alveoli and bronchial bifurcations of the lung and on bone surfaces, relatively high (in some instances exceedingly high) doses are presented to very localized tissue. The current standards are based on the assumption that the risk to the organ from such localized exposures is not greater than the risk assuming that the energy deposited by the alpha radiation is uniformly distributed throughout the organ.

There are three important examples where various experts have argued that the current treatment of non-uniform exposure to alpha emitters is nonconservative by two or three orders of magnitude. One of these is based on the arguments set forth by Dr. Karl Z. Morgan (who was primarily responsible for deriving the current standards related to maximum permissible internal organ exposure) in his article in the Journal of American Hygiene (Aug. 1975), and described briefly in his testimony. On the basis of the evidence described in his article, Morgan argues that the current plutonium standard is too high by a factor of approximately 200. Accepting Morgan's thesis, in order to provide adequate protection to the public (and radiation workers), one should increase the quality factor used in calculating the bone dose (in rems) by a factor of 200, or use the currently assumed quality factor and reduce the standards by the same factor.

A second example of possible nonconservatism is the hypothesis that the principal causal factor in tobacco-related

carcinoma is a result of inhalation of Po-210 (an alpha emitter) in cigarette smoke.[13] This hypothesis, often referred to as the "warm particle hypothesis," has been argued most recently in a series of Letters to the Editor appearing in the New England Journal of Medicine Vol. 307, 29 July 1982, at pp. 309-313. Here it is noted that the localized distribution of Po-210 in the bronchial region of the lung "now appears to be 1000 times more carcinogenic than gamma radiation -- as compared to the factor of 10-20 currently assumed." Id. Dr. John C. Cobb also cites the Po-210 work as part of the basis for his view that "present and proposed standards or guidelines for plutonium and other alpha-emitting radionuclides like americium and uranium may be seriously inadequate to protect the public." Testimony of Dr. John C. Cobb at pp. 1-2.

A third example of possible nonconservatism is the "hot particle hypothesis," a variation of the "warm particle hypothesis" based on the Po-210 evidence. The hot particle hypothesis was supported by Arthur R. Tamplin and myself in a series of NRDC reports.[14]

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[13] See, e.g., Martell, E.A., Nature, 249, 214-218 (May 17, 1974); Martell, E.A., New Scientist, 63, 404-412 (July-Aug. 1975).

[14] See, e.g., Radiation Standards for Hot Particles, NRDC, February 14, 1974; NRDC Comments on WASH-1535, DRAFT EIS LMFBR Re Volume II, Part 2, Section 4.6.5, Particle Lung Dose Effects, reprinted in ERDA-1535, pp. V.55-1 to V.55-328; "NRDC Supplemental Submission to the EPA Public Hearings on Plutonium and the Transuranic Elements," February 24, 1975; and NRDC testimony in the GESMO Proceeding (Dkt. No. RM-50-5), Re: Chapter IV, Section J, Appendix D, March 4, 1977, Prepared by Arthur R. Tamplin and Thomas B. Cochran.

Although this hypothesis has been criticized by a number of people and organizations, including the Nuclear Regulatory Commission, none of these groups or individuals have responded to the rebuttals to their arguments prepared by Dr. Tamplin and myself. See The Hot Particle Issue: A Critique of WASH-1320 as it relates to the Hot Particle Hypothesis, November 1974; "A Critique of the Biophysical Society DRAFT Comments on 'Radiation Standards for Hot Particles'," December 1974; "Comments by NRDC on the NRC's Denial of Petition for Rulemaking [Docket No. PRM-20-50]," June 2, 1976; and "Natural Resources Defense Council Critique of the NAS-NAC Report, 'Health Effects of Alpha-Emitting Particles in the Respiratory Tract," March 1977. I remain convinced that this hypothesis has not been disproven.

None of these hypotheses are proof that the risks of "hot spots" of alpha emitters is as high as the respective hypotheses would indicate. But the hypothesis currently accepted by Staff and Applicants -- that the risk associated with these hot-spots can be conservatively treated by assuming the alpha irradiation is smeared uniformly throughout the organ -- is also unproven . One cannot use one hypothesis to set aside another. This is nothing more than a case where the data allow for a wide range of interpretation and different experts have widely divergent views on the matter. In this regard it is instructive to examine the BEIR-III review of the "hot spot"

issue in its discussion of lung cancer:[15]

> The possible influence of "hot spots" of insoluble radioactive particles deposited in pulmonary tissues on cancer risk has been evaluated in a previous report.32/ The evidence is still insufficient to det[illegible] whether aggregates of radioactivity that remain localized in specific regions of the lungs give a greater or smaller risk of lung cancer per average lung dose than uniformly deposited radiation. Preliminary experimental data indicate that a small fraction of inhaled insoluble particles may remain in the bronchial epithelial layer for long periods, but the significance of this local exposure on lung-cancer risk is still uncertain.
>
> 32/ National Research Council, Advisory Committee on the Biological Effects of Alpha-Emitting Particles in the Respiratory Tract. Washington, D.C.: National Academy of Sciences, 1976

Based on these uncertainties in dose and health effects models, a factor reduction of the dose guidelines for lung and bone at the CP and LWA stages is not only appropriate, but absolutely necessary. I believe these dose reduction factors should be approximately 100 for bone surface and 100-1000 for lung, assuming the quality factors assumed by the Staff are used in calculating doses. These factors would lower the lung guideline value to .75 rems and the bone surface guideline value to .03-.3 rems for purposes of CP & LWA review.

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15 BEIR III, p. 326 (emphasis added).

IV. Neither Applicants Nor Staff Have Established That the Models, Computer Codes, Input Data and Assumptions Used to Analyze CDAs and Their Consequences Are Valid

Intervenors' Contention 2(f) challenges the validity of the models and computer codes used by the Staff and the Applicants in their safety analyses of CDAs and their consequences. Contention 2(g) challenges the validity of the input data and assumptions used by the Staff and the Applicants in those computer codes and models. Contention 2(h) challenges the proposed source term since it is not based upon an adequate analysis of CDA energetics.

With regard to the Staff's site suitability source term analysis, the Staff has stated that it does not analyze or rely upon the energetics of a CDA or the magnitude of its release to the secondary containment. Rather, the Staff's site suitability analysis begins with the postulated release of the assumed source term to the secondary containment. The Staff analyzes the dose consequences of this postulated release using three computer codes:

1) HAA-3;

2) PAVAN; and

3) TACT;

The HAA-3 code is used to model the behavior of aerosols in the containment. I have not analyzed the HAA-3 code due in part to the fact that the Staff claimed at the Conference With Parties on August 2, that it was using HAARM rather than HAA-3

(Transcript of Conference with Parties, Aug. 2, 1982, at p. 850.) The Staff corrected this error on August 6, 1982, only 10 days ago. Letter from Daniel T. Swanson to Administrative Judges dated August 6, 1982. The Staff claims that the HAA-3 code is also used by the Applicants. Id. Applicants, however, use HAA-3B, a later version of HAA-3. PSAR, P. A-140.

On August 6, the Staff informed Intervenors for the first time that it also uses the PAVAN code to calculate the X/Q values subsequently used in TACT. That same day, the Staff supplied Intervenors with a draft users guide for PAVAN.[16] There is no evidence that a formal code review process has been conducted. The fact that only a draft users guide is available suggests that no such review has been conducted. Consequently, the reliability of the code is questionable.

The TACT code is used by the Staff to calculate the whole body and organ doses for a given SSST release. THe X/Q values and the dose conversion factors (DCFs) (e.g., rem/cure inhaled) are code inputs. The Staff provided Intervenors on August 6, 1982 with a copy of a TACT programmers manual,[17] which

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[16] Bander, T.J., DRAFT "User's Guide for PAVAN: Evaluating Non-Routine Releases of Radioactive Materials from Nuclear Power Stations," Batelle NUREG/2858 PNL - , June 1982.

[17] R. George, F.G. Prohammer, F.E. Dunn, "TACT Programmers Manual, ANL, undated.

includes a printout of the code, along with sample TACT calculations (i.e. output). The Staff informed me, however, that unspecified modifications to the code have been made subsequent to the time the programmers manual was written, which, incidently, is undated.

As indicated in Dr. Morgan's testimony, incorporated herein by reference, no documentation exists -- at least none was provided -- for the DCFs assumed by the Staff as input for the TACT code calculations. Given the inadequacies of the documentation of the TACT and PAVAN codes, the Staff's calculations cannot be accepted as reliable.

Applicants claim to use the SAS3D, PLUTO, VENUS, REXCO-HEP, COMRADEX III, CACECO, and HAA-3B codes in their site suitability analysis. (Transcript of Conference with Parties, Aug. 2, 1982 at 844-846); PSAR Appendix A).

The SAS3D, PLUTO, VENUS and REXCO-HEP codes are used to analyze CDAs and their consequences within the reactor vessel Applicants claim that they do not rely on analyses of CDA energetics or these codes as a basis for their view that the CDA should not be considered within the DBA envelope (Contention 1) and claim that any discussion of these codes is limited to the scope of the 1982 SSR, pp. II-18 - II-19. Transcript of Conference With Parties, supra, at p. 851. Applicants have also stated in deposition that they will not challenge the validity of the Staff's assumed SSST, filter efficiencies, or assumed leakrates in the LWA-1 proceeding.

(Transcript of Deposition by Intervenors George H. Clare, Neil W. Brown, and L. Walter Dietrich, June 16, 1982 at 139-141). For these reasons, and because I believe that the Board may not rely upon Applicants' codes before they have been reviewed by the Staff, Intervenors will not present a detailed review of Applicants' codes at this time. The importance of an independent Staff review of any of Applicant's codes that are presented as a basis for LWA-1 decisions is evident from the following observations:

(1) Memorandum from G.F. Flanagan, Oak Ridge National Laboratoary to Distribution dated August 13, 1976:

> Because the magnitude of the work estimated [CDA energy release] using these "crude" models was excessive when extrapolated to large commercial plants, a large effort was initiated primarily at ANL and later at HEDL and LASL, to mechanistically model the disassembly so as to reduce the energy release.
>
> This resulted in several series of codes being developed such as SAS, VENUS, REXCO, MELT, etc... Their prime purpose was to further the understanding of the behavior of fuel, coolant and cladding before and during a core disruptive accident. They were never intended to supply an absolute number for the work or energy release for purposes of reactor design. . . .
>
> On the surface these codes appear mechanistic and probably this is the reason the results are represented as design numbers. However, on close examination the models in the codes are based on small out-of-pile experiments, simplified in-pile experiments, tradition and hypothesis. Many parameters are left to the user to determine which actually regulate the sequence, timing, and ultimate energy release of the accident being investigated. To quote a developer of one of the codes, "we parameterized our ignorance". This is not

> to say that the codes are not useful because they are when used for the purpose intended, to study the effects of various input data changes on a particular accident, model comparison, etc., but not for the purpose of supplying the design basis data. Thus the problem boils down to a question of, "do we have the capability to predict the mechanistic disassembly of a reactor during an accident to the accuracy required if such an accident is declared a design basis accident (DBA)?" The answer is "no" and further the task is so enormous that it is unlikely we will be able to obtain the accuracy and reduce the uncertainties without a considerable investment in money and time both experimentally and analytically. (Emphasis supplied.)

In a handwritten note on this memo is the note "This could be sensitive material please treat it as such."

One of the important points Flanagan makes is that the codes "parameterize our ignorance," and consequently the energy release and therefore the source term is regulated by the users' input assumptions. These assumptions are often design specific. But more importantly, these parameters have not been reviewed by the Staff.

(2) Another indication of the need for an independent analysis of Applicants' codes relates to the Applicant's analysis of CDAs in the new heterogenous core, which is documented in CRBRP-GEFR-00523. SAS-3D was developed directly from SAS-3A using the same physical models and SAS-3A is cited by Applicants as a basis for the validity of SAS-3D. The major differences between SAS-3A and SAS-3D are in the treatment of data management and reprogramming to obtain better efficiency.

SAS-3A has been supplemented, however, by an even later version, called SAS-4A. Some of the differences between SAS-4A and SAS-3A were summarized as follows in a paper by Cahalan, et al.:[18]

> However, experience gained through application of SAS3A pointed out areas where improved models and numerical techniques would significantly strengthen and expand the understanding of core disruptive accidents.
>
> . . . .
>
> In order to obtain an improved physical model, a more accurate numerical solution, and a reduction in computer time, the SAS4A transfer routines have been completely rewritten and are significantly changed from those in previous versions of SAS.
>
> . . . .
>
> The SAS4A coolant boiling model [9] is an extended and totally reprogrammed version of the SAS3A coolant boiling model [4]. The one-dimensional, multiple bubble framework has been retained, but a number of numerical and phenomenological improvements have been made to improve the ability, efficiency, and applicability of the model.

Because SAS-3D incorporates the same physical models as SAS-3A, these improved models incorporated in SAS-4A are also improvements over the physicasl models in SAS-3D. In discussing the CRBR transient overpower accident, Mr. Hummel, a

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[18] Cahalan, et al., "The Status and Experimental Basis of the SAS-4A Accident Analysis Code System," paper presented at the Fast Reactor Safety Technology Conference in Seattle, August 1979.

Nuclear Regulatory Commission consultant from Argonne National Laboratory, recently testified:

> And for some reason, the heat transfer calculations in SAS-3D and SAS-4A are sufficiently different that you get by all right with 10 cents a second for SAS-4A and you do not with SAS-3D. We have not sorted this out yet, but I wanted to mention it as an important variable.[19]

It should be little comfort to those using SAS-3D that it gives the more conservative result in this particular instance if the model is predicting erroneous results.

(3) In the May 1 - Aug. 31, 1981 Foreign Attaches Quarterly Report prepared at Sandia National Laboratory, the authors state:

> Several errors and seeming inconsistencies were detected in the SAS3D input manual and code. To date, investigators have not been able to obtain a consistent accident sequence involving an overpower excursion leading to the fuel-pin rupture and subsequent fuel-coolant interaction. Part of the problem has been due to the lack of complete documentation on the SAS3D code and possibly an inadequate check-out of the SAS3A to SAS3D modifications for UTOP accident sequences.

W. Breitung, F. Briscoe, G. Fieg and P. Herter, "Limited Distribution Foreign Attaches Quarterly Progress Report," Sandia National Laboratory, May 1 - Aug 1, 1981 (emphasis added). These observations were made before most, if not all, of the Applicants' site suitability CDA analyses were performed.

(4) Intervenors, through discovery, obtained a memorandum from the chief engineering officer of the Clinch River

project[19] to the Chief of the division responsible for planning, development, coordinating and executing policies and plans in the areas of public safety, environmental affairs, nuclear safeguards, licensing, and reliability[20] concerns a report numbered ANL/RAS 77-15 prepared by Argonne National Laborataries. The Argonne report in question is one of the fundamental underpinnings of the CRBR accident analysis. It constitutes the principal technical documentation for the validity of the computer code (SAS-3D) used to calculate the occurrence potential, accident progressions, and nuclear explosive potential of the CRBR core.[21] The Riley memorandum calls unambiguously for the systematic deletion from the Argonne report of "negative" information that would presumably interfere with the licensing of the facility. For example:

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19 The Engineering Division, headed during the pertinent time by the author of this memo, is responsible for management of the design, engineering, and fabrication of systems, processes, equipment, and facilities, including quality, cost estimates, schedule, and research and development activities. CRBR PSAR, 1.4-5 (Am. 66, March 1982).

20 Id.

21 See CRBRP-3, Hypothetical Core Disruptive Accident Consideration in CRBRP, Vol. 1, Energetics and Structural Margin Beyond the Design Base, 2 Jan. 1979, Rev. 3, Aug. 1981 and 4 March 1982; see in particular pp. 1-4 and C-3.

General Comments

1. The subject report is not acceptable because the information is presented in a very negative manner, particularly Chapter 2. The overall conclusion derived from Chapter 2 is that significant uncertainty exists in the Project's knowledge of all the major phenomenon which contribute to the initiation phase of a loss-of-flow (LOF) accident for an end-of-equilibrium cycle (EOC) core. The report should not only present to NRC our current understanding of the LOF/EOC accident and the basis for this knowledge, but also the results and descriptions of the SAS-3D analysis. This report should be written in a straightforward, positive manner.

2. Any reference in this report to the need for additional work either experimental or analytical should be deleted. This type of information is not appropriate for transmittal to NRC.

Specific Comments

. . . .

Chapter 9 - This chapter which presents the conclusions should be completely rewritten. Not only does this chapter support Chapter 2, i.e., the Project does not understand the LOF-EOC event, but it also presents to NRC a list of additional experiments which should be performed, see comments G1 and G2.

Recommendation

The critical chapters 1, 2, 7, 8 and 9 should be rewritten to a) present a positive, real assessment of the LOF HCDA, b) delete any reference to additional analytically [sic] or experimental work andc) incorporate the preceding comments. Until this is accomplished, Engineering does not recommend transmittal of this report to NRC.

Memorandum, pp. 1-2, 4 (emphasis added).

Although the memorandum was written in 1977, the Argonne Report is still the primary documentation of the validity of the SAS-3D code.[22] Although Applicants claim that the recommended changes were not included in the final ANL/RAS 77-5 report, the fact that an Applicant (or its highest technical management personnel) would direct that NRC be kept purposely ignorant of the limitations of its safety analyses should make it clear that Applicants' codes should not be relied upon without independent Staff review.

V. Conclusion

In summary, I believe that the Staff's site suitability analysis contains many omissions, inconsistencies, and nonconservatisms which, when corrected, demonstrate that the proposed site is not adequate to protect the public health from accidents at a reactor of the general size and type as CRBR. In particular, the Staff's failure to base its assumed fission product release upon a major core disruptive accident (since such accidents are credible, and, at

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22 It is relied upon in the latest pertinent licensing documents (a) General Electric Co., "AN ASSESSMENT OF HCDA ENERGETICS IN THE CRBRP HETEROGENEOUS REACTOR CORE," CRBRP-GEFR-00523, Dec. 1981, p. 1-3, Chapter 3 and Appendix A; (b) US DOE, CRBRP-3, supra n. 7; US DOE, "Final Environmental Impact Statement, Liquid Metal Fast Breeder Reactor Program (Supplement to ERDA 1535, Dec. 1975)", DOE/EIS-0085-FS, May 1982, pp. 132, 145.

the very least, cannot be proven incredible without a full safety review), and its failure to evaluate conservatively the consequences of such an accident, including containment overpressurization and high thermal loadings that would result from sodium fires and sodium-concrete interactions, renders the entire source term analysis inadequate. Even if the Board accepts the Staff's nonconservative source term, the postulated radiological doses to the nearby population are in reality much greater than those derived by the Staff. Correcting the Staff's errors in these offsite radiological doses would prove that they are too large to meet either the Staff's proposed guidelines, which we contend are inadequate, or the appropriate guideline values suggested by Dr. Morgan and myself. Conversely, the Staff's postulated offsite doses are not low enough to meet the appropriate dose guideline values for lung and bone surface based on recommendations by the ICRP, the EPA, or the testimony you've heard today. As a result, the site for a reactor of the general size and type as CRBR does not provide adequate protection to the public health.

BEFORE THE
UNITED STATES NUCLEAR REGULATORY COMMISSION
ATOMIC SAFETY AND LICENSING BOARD

In the Matter of UNITED STATES DEPARTMENT OF ENERGY PROJECT MANAGEMENT CORPORATION TENNESSEE VALLEY AUTHORITY (Clinch River Breeder Reactor Plant)	Docket No. 50-537

AFFIDAVIT OF DR. THOMAS B. COCHRAN

City of Washington)
) ss:
District of Columbia)

I, Dr. Thomas B. Cochran, being duly sworn, depose and say that the foregoing testimony is true and correct to the best of my knowledge and belief.

Dr. Thomas B. Cochran

Subscribed and sworn to
before me this 16th day
of August 1982.

Barbara Pratt
Notary Public

October 1, 1981

RESUME

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EMPLOYMENT HISTORY

April 1973-present: Natural Resources Defense Council, Inc.

Senior Staff Scientist, focusing on national energy R&D policy, principally nuclear energy issues, the breeder reactor, plutonium recycle, nuclear weapons proliferation, safeguards, and radiation exposure standards. Consultant to the U.S. Department of Energy (DOE) on nuclear nonproliferation and nuclear R&D strategy; consultant to the Comptroller General on (a) U.S. and international controls over the peaceful uses of nuclear energy, (b) Advanced Nuclear Technologies, and (c) U.S. Liquid Metal Fast Breeder Reactor Program; consultant to the Office of Technology Assessment (OTA); Member of DOE's Energy Research Advisory Board, DOE's Nonproliferation Advisory Panel, OTA's Advisory Panel on Nuclear Proliferation and Safeguards, the Nuclear Task Group of OTA's Analyses of the ERDA Plan and Program, and OTA's Gas Curtailment Study Review Panel. Consultant to Governor of Lower Saxony, West Germany, to serve as an International Expert in the Review of the Gorleben Nuclear Fuel Cycle Center. Served as a member of ERDA's LMFBR Review Steering Committee, the National Academy of Sciences' Panel on Strategy for Developing Nuclear Merchant Ships, the Task Force on Energy Conversion Research and Development of the Federal Power Survey, the United Nations' Environment Programme's International Panel of Experts on Energy and the Environment, the National Council of Churches' Energy Study Panel and the World Council of Churches Consultation on Ecumenical Concerns in Relation to Nuclear Energy. Also served as a consultant to Resources for the Future and numerous environmental organizations. Testified before Congress and federal agency hearings on numerous occasions, including testimony before the Joint Committee on Atomic Energy, the House Committee on Interior and Insular Affairs, the Joint Economic Committee, the House Committee on Small Business, and the Nuclear Regulatory Commission's Advisory Committee on Reactor Safeguards.

June 1971-April 1973: Resources for the Future, Inc.
Washington, D.C.

Senior Research Associate, Quality of the Environment Program. Studying environmental effects of the U.S. civilian nuclear power industry, residuals management in the nuclear fuel cycle, liquid metal fast breeder reactor program, national energy policy, and radiation standards. Wrote a book, The Liquid Metal Fast Breeder Reactor: An Environmental and Economic Critique.

1969-1981: Litton Mellonics Division, Scientific Support Laboratory
Fort Ord. California

Modeling and Simulation Group Supervisor. Supervised the activities of 10 operation research analysts engaged in military research pertinent to the evaluation of proposed U.S. Army concepts and material by U.S. Army CDCEC.

1967-1969: U.S. Naval Postgraduate School
Monterey, California

Lt-USNR, Active Duty; Assistant Professor of Physics; Radiation Safety Committee; part-time research involving computer studies of synchrotron radiation production in beam transport systems at Stanfard Linear Accelerator, Stanford, California.

EDUCATION

Summer 1969: University of Colorado, Boulder. Postdoctorate. Summer Institute of Theoretical Physics.

1965-1967: Vanderbilt University, Nashville, TN. Doctorate. Major: Physics. Minor: Mathematics. Research in high energy (bubble chamber) physics. NASA Fellowship. Guest Research Associate in Physics Department at Brookhaven National Laboratory, Upton, NY, studying synchrotron radiation shielding problems.

1962-1965: Vanderbilt University. MS degree in Physics. Research in radiation chemistry; AEC Health Physics Fellow; applied health physics training, Oak Ridge National Laboratory; Vanderbilt University Campus Radiation Safety Officer.

1958-1962: Vanderbilt University. BE degree in Electrical Engineering, cum laude. NROTC.

PROFESSIONAL AFFILIATIONS

American Physical Society
Maerican Nuclear Society
Health Physics Society
Sigma Xi

PERSONAL

Age: 40. Birth date: 18 November 1940. Birth place: Wash. DC. Wife: Carol J. Cochran. Two children.

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BEFORE THE
UNITED STATES NUCLEAR REGULATORY COMMISSION
ATOMIC SAFETY AND LICENSING BOARD

In The Matter Of UNITED STATES DEPARTMENT OF ENERGY PROJECT MANAGEMENT CORPORATION TENNESSEE VALLEY AUTHORITY (Clinch River Breeder Reactor Plant)	Docket No. 50-537

TESTIMONY OF DR. JOHN CANDLER COBB

NUCLEAR REGULATORY COMMISSION
Docket No. 50537 Official Exh. No. 8
In the matter of Clinch River
Staff ____ IDENTIFIED ____
Applicant ____ RECEIVED ____
Intervenor — REJECTED ____
Cont'g Off'r ____ DATE 8-27-82
Contractor ____ Witness ____
Other ____
Reporter M

August 12, 1982

My name is Dr. John Candler Cobb. I reside at 4824 East 6th Avenue, Denver, Colorado 80220. I am presently Professor of Community Health in the Department of Preventive Medicine and Biometrics at the University of Colorado School of Medicine in Denver, Colorado; from 1966 to 1973, I was Chairman of this Department. In 1974, I was appointed by Governor Lamm and Congressman Wirth of Colorado to be a member of the Lamm-Wirth Task Force on Rocky Flats Plutonium Weapons Facility near Denver, Colorado; from 1976 to 1979 I served as Commissioner representing the State Board of Health on the Air Pollution Control Commission of Colorado; and I have served on a number of other State and National advisory groups and task forces. From 1975 to 1982, my primary research activity has been as Principal Investigator on a U.S. Environmental Protection Agency (EPA) contract to study human plutonium burdens in people who had lived near the Rocky Flats Nuclear Weapons Facility. The final report of this research project was submitted to the EPA last December, under EPA contract #68-03-2217.

The purpose of this testimony is to offer evidence with regard to Intervenor's Contention 2. I am concerned that present and proposed standards or guidelines for plutonium and other alpha-emitting radionuclides like americium and uranium may be seriously inadequate to protect the public. Consequently calculations based on these standards or guidelines may be wrong in concluding that a maximum credible accident would not present a health risk to the nearby population.

I believe that where the health of the public is concerned, we should be conservatively cautious. We should not permit the development of a huge industry based on plutonium until the questions of safety for present and future generations have been more carefully evaluated.

My concern is based on the findings of recent research in four related areas:

1. The findings of our EPA-contracted study of plutonium burdens in the post-mortem tissues of people who had lived near the Rocky Flats plutonium weapons facility.
2. The findings of several epidemiological studies showing an excess of cancer mortality and incidence in the areas near to and downwind from Rocky Flats.
3. The findings of animal experiments suggesting that at very low dose rates, alpha-emitters like ^{239}Pu and ^{210}Po are very much more carcinogenic than had previously been suspected, perhaps by as much as a hundred times.
4. The findings of animal experiments showing that plutonium and other alpha-emitters cause mutations and genetic defects as well as cancers.

The public has a right and a need to know what the risks may be. Our EPA plutonium human burden study was undertaken in 1975 by Russell Train, then Administrator of EPA, at the request of Senator Floyd Haskell in response to the great concern about possible dangers from the Rocky Flats plutonium weapons facility among his constituents in Colorado. Citizens are now, more than ever, interested in knowing the

results of this tax-supported research project done on their behalf.

Let me emphasize that, at this stage, the data available do not prove that the EPA proposed guidelines are inadequate, but there are enough indications in the available data to cause a conservative person to be concerned. It would be unfortunate for the population of this country if promulgation of the proposed EPA guidelines for plutonium in the environment were to result in the relaxation of the present stricter Colorado State guidelines; and if then after some time, the more serious dangers to human populations became evident.

I have read the 20 September 1981 report by Stephen Chinn and the paper by Carl Johnson presented at the AAAS on 4 January, 1982 and also the review of an earlier draft of Chinn's report which was done by Richard G. Cuddihy and William C. Griffith under US Dept. of Energy Contract No. DE-AC04-76EV10103. This most recent report by Chinn addresses the criticisms raised by Cuddihy and Griffith. Considering Chinn's research together with similar studies by Dr. Carl Johnson and the findings of our EPA plutonium human burden study, I am left with the uneasy feeling that while the issue is far from settled, there is substantial reason for concern regarding the adequacy of the proposed guidelines. Before EPA promulgates these proposed guidelines, therefore, further investigation would be prudent.

Let me state briefly some of the findings which lead to my concern:

A. Chinn's and Johnson's studies show an excess of more than ten percent in the cancer incidence (more than a hundred excess cases of cancer in three years) among people living in the areas known to be contaminated with weapons grade plutonium evidently released from Rocky Flats.

B. Our study showed that some weapons grade plutonium (presumably from Rocky Flats) had gotten into the lungs of people living in this plutonium-contaminated area. The total amount of plutonium from all sources in the lungs of our study population was very small, the average being about 0.2 picocurie per person, which is very near the limit of detectability by the methods used at McClellan Airforce Base Laboratory where the plutonium measurements were done.

C. Compared with lungs, the liver retains plutonium for a much longer time (mean residence time approximately 40 years for liver, 1.3 years for lung). The total amount of plutonium found in the livers of our study population was, thus, roughly an order of magnitude larger (average about 1.5 picocuries per person); and, in general, a smaller fraction of it was found to have been weapons grade plutonium (presumably because the plutonium from global atmospheric fallout was added to the weapons grade plutonium from Rocky Flats. However, our analysis did show that the people who had been living within 50 km east and south of the Rocky Flats plant at the time of the 1957 plutonium fire at Rocky Flats, had a slightly larger fraction of weapons grade plutonium in their livers than did those who had been living more than 50 km away from the plant at that time. We were quite surprised that this difference should still be detectable and statistically significant twenty years later, considering the continued deposition of plutonium from world-wide fallout over the twenty year period. This finding is, however, consistent with the hypothesis that there may have been a considerable exposure to

weapons grade plutonium (and possibly other mutagens also) for people living downwind and within 50 km of the plant at the time of the 1957 fire.

The reason for my concern is that if the exposure to plutonium resulting from the 1957 fire were indeed the cause of the 10% excess of cancers which showed up twelve to fifteen years later in the population of that area, then it would follow that the EPA proposed guidelines for alpha-emitting transuranium isotopes may be seriously too lenient. This conclusion follows logically from our EPA plutonium burden study finding that the total amount of plutonium in the tissues of our study population was exceedingly small and that people who had lived within 10 km of Rocky Flats could only have had at most about 50% more plutonium in their tissues, on the average, than did those living 50 km or more away. Let me emphasize again that plutonium is not proven to be causally related to these cancers, but it does seem to be a reasonable possibility. To settle this important question, we need to know the amount of plutonium released in 1957 and whether other carcinogens may also have been involved; and we need to find out whether, in recent years, the incidence of cancer and genetic defects has become progressively higher in long-term residents of the affected area, relative to unaffected areas, as would be expected if the cause were plutonium exposure which occurred 25 years ago.

Four studies should be done:

1. Measurement of plutonium, americium, uranium and other carcinogens and mutagens in sediments deposited during the years 1952-62 in Standley Lake.

2. Measurement of americium-241, uranium and other carcinogens and mutagens in the remaining aliquots and tissue samples from the EPA Plutonium Human Burden Study.
3. Repeat of the cancer incidence epidemiological studies for the period 1979-81.
4. Epidemiological study of the incidence of genetic defects in the affected area.

1. Sediment Examination

It is important to find out how much plutonium, other radionuclides and other carcinogens were dispersed into the environment during the 1957 fire and other events at Rocky Flats. Examining the sediment layers in a core sample from Standley Lake, which is a few miles southeast of Rocky Flats, would provide data on the relative importance of the 1957 releases compared with the already documented more recent released of plutonium during the 1960's.

There was a study done by E.P. Hardy and others of the Environmental Measurementss Laboratory of the Department of Energy which was reported in July 1978 in the Quarterly Report of US DOE, EML-342, I-123 under the title "Time Patterns of Offsite Plutonium Contamination from Rocky Flats Plant by Lake Sediment Analysis." Unfortunately they only reported their findings up to a depth of 50 cm in the Standley Lake sediment; so their analysis goes back only to 1962. That core sample did show the peak of plutonium contamination presumably coming from the oil-drum barrel spills at Rocky Flats during the late 1960's; but as pointed out above, it failed to go deep enough to provide information about the sediment deposited during the period of the 1957 fire. A new

study should be done on a deeper core sample, and it should look for other carcinogens and radionuclides, besides plutonium, which might be expected from that fire. There may, for example, have been some carcinogenic organic compounds in the smoke from that fire, as well as plutonium, americium, uranium and other radionuclides. Other events, like the disposal by burning at Rocky Flats of thousands of gallons of cutting oil containing uranium, could also be related to the excess cancers and could be evaluated by such a study of these sediments. In addition, sediment samples from the North Table Mountain Reservior near Golden should be studied to evaluate the possible contribution from the Schwartzwalder uranium mine which drained into that water system.

2. Analyses of remaining samples from our EPA Plutonium Human Burden Study

The bones, gonads and adrenals, which were collected from the 519 autopsies for the plutonium burden study, are still waiting in the freezers at the Lawrence Radiation Lab for someone to proceed with the planned analyses. Aliquots of the dissolved livers and lungs are also still being stored at EPA, Las Vegas, waiting for the planned analyses for americium and other elements. So far, they have only been analysed for plutonium. Completion of these planned analyses would provide important data for deciding whether plutonium, alone or together with other carcinogens, may have been the cause of the observed excess incidence of cancer in the area.

3. Cancer Incidence Study

Since many cancers caused by low level radiation have a latency period of up to 20 to 30 years, we would expect cancers caused by a low

level radiation exposure in 1957 to have their peak incidence in the 1980's. A repeat of the Johnson and Chinn studies for more recent years should be done as soon as possible. I understand that Dr. Johnson is doing this now under a grant from NCI.

4. An epidemiological study of genetic defects in the population downwind from Rocky Flats should be undertaken. If the exposure to plutonium and/or other radionuclides coming form the 1957 fire at Rocky Flats caused an increase in genetic defects in the population downwind, it might be revealed by a careful study of the incidence of such defects in children born during the years subsequent to 1957, comparing that population with the population living in upwind areas and with children born before 1957. Similar studies of domestic animals, cattle and horses, in these areas should also be done.

Until at least, these four studies can be completed, I think it would be foolhardy to permit the development of a huge new breeder reactor industry which would put into commercial circulation as much as 5 billion grams of plutonium per year.

NRC done for Plutonium based on ICRP-2

Present guidelines, which may be far too lenient, allow only 8 billionths of a gram as the maximum permissible lung burden of plutonium. (If each of the four billion people in the world had this maximum permissible amount of lung burden, the total amount of plutonium would add up to only 32 grams, about one ounce). No other substance used by industry in such large quantities is any where near as toxic as plutonium. Can we be sure enough of our technology to handle as much as five billion grams of plutonium per year, when 8 billionths of a gram is dangerous to inhale?

My concern is that we may have underestimated the toxicity of plutonium by a large factor; and we have probably overestimated our ability to control it, as shown by our experience with the Rocky Flats plutonium weapons facility.

BEFORE THE
UNITED STATES NUCLEAR REGULATORY COMMISSION
ATOMIC SAFETY AND LICENSING BOARD

In The Matter Of

Docket No. 50-537

UNITED STATES DEPARTMENT OF ENERGY
PROJECT MANAGEMENT CORPORATION
TENNESSEE VALLEY AUTHORITY

(Clinch River Breeder Reactor Plant)

AFFIDAVIT OF DR. JOHN CANDLER COBB

City of Denver
ss:
State of Colorado

I, Dr. John Candler Cobb, being duly sworn, depose and say that the foregoing testimony is true and correct to the best of my knowledge and belief.

Dr. John Candler Cobb

Subscribed and sworn to
before me this 12 day of
August 1982.

Notary Public

CURRICULUM VITAE

PERSONAL DATA:

Name: COBB, John Candler

Home Address: 4824 East Sixth Avenue, Denver, Colorado 80202
Phone: (303) 333-4737

Date of Birth: 8 July 1919

Place: Boston, Massachusetts

Marital Status: Married (Holly Imlay-Franchot) 27 July 1946
Four children

Present Position: Professor of Preventive Medicine, Community Health
University of Colorado Health Sciences Center
4200 East Ninth Avenue, Denver, Colorado 80262
Phone: (303) 394-5177

EDUCATION-DEGREES:

1941 - Bachelor of Science (B.S.) Harvard University (Astronomy, cum laude)

1948 - Doctor of Medicine (M.D.) Harvard University

1954 - Master of Public Health (M.P.H.) Johns Hopkins University School of Hygiene and Public Health, in Maternal and Child Health (MCH)

AWARDS AND HONORS:

1979 - Colorado Public Health Association, Florence Sabin Award (for outstanding contributions to public health)

1980 - American Friends Service Committee, Colorado Area Committee
Jack Gore Memorial Peace Award (for contributions to the cause of world peace)

CERTIFICATION AND LICENSURE:

Diplomate National Board of Medical Examiners 1948

Fellow American Public Health Association 1955

Diplomate American Board of Preventive Medicine and Public Health 1961

Licensed to Practice Medicine in Connecticut, Maryland, New Mexico

EMPLOYMENT EXPERIENCE:

1941-42 Friends Service Committee (malaria control work) Mexico

1942-44 American Field Service (ambulance driver) Syria, North Africa, Italy

1948-49 Intern in Pediatrics, Yale New Haven Hospital

1949-50 Fellow in Pediatrics, Yale New Haven Hospital

1950-51 Jr. Assistant Resident in Psychiatry, Yale Psychiatric Clinic

1951-54 Instructor, Maternal & Child Health, Johns Hopkins University, School of Hygiene and Public Health

1951-56 Instructor, Pediatrics, Johns Hopkins School of Medicine

1952-56 In tructor, Psychiatry, Johns Hopkins School of Medicine

1954-56 Assistant Professor MCH, Johns Hopkins School of Hygiene

1956-60 Area Consultant in MCH, U. S. Public Health Service, Division of Indian Health, Albuquerque Area Office

1960-64 Director, Medical Social Research Project, Lahore, Pakistan, with Johns Hopkins School of Hygiene and University of the Panjab, supported by Ford Foundation and Rockefeller Foundation through the Population Council

1965- Professor of Preventive Medicine, University of Colorado School of Medicine

1966-73 Chairman, Department of Preventive Medicine, University of Colorado School of Medicine

1969-70 Short-term consultant for WHO in Indonesia on Strengthening Health Services (M.C.H. and F.P.) (3 months)

1972-73 Short-term consultant for WHO in Western Pacific Region (Philippines, Korea, Vietnam, Fiji, etc.) on Family Health Education (6 months)

1977-78 Consultant to Project Hope, Rural Health Program in Tunisia (1 month)

1979 Consultant to Ministry of Health, Government of Togo (Family Health Training) (3 months)

1980-81 Acting Chairman, Department of Preventive Medicine, University of Colorado School of Medicine (4 months)

1975-82 Principal Investigator in U.S. Environmental Protection Agency. Contract to study human plutonium burdens in people who have lived near the Rocky Flats Nuclear Weapons Plant

JOHN CANDLER COBB, M.D., M.P.

EXTRA-CURRICULAR/HEALTH-RELATED ACTIVITIES - 1966-1982

Denver City and County:

1968-69 Board Member, Central Area Health Planning Association

1969 Chairman, Task Force for Preparing 314(b) Agency Grant Application

1969-72 Chairman, Commission on Public Health of Denver Medical Society

1981- Member, Ethics Committee, Denver Medical Society

State and Regional:

1966-68 Board Member, Planned Parenthood Association of Colorado

1966-69 Member, Regional Advisory Group, Colorado-Wyoming Regional Medical Program

1967-70 Board Member, Colorado Public Health Association

1968-69 Member and Chairman, Committee on Health Services for the Poor of Regional Medical Program

1969-71 Member, Task Force on Prevention for State Comprehensive Health Planning Council

1969-73 Executive Committee, Colorado Area Office of American Friends Service Committee

1970 Member, Program Committee for Colorado Interaction Conference on Medical Care, sponsored by Medical Society, UCHSC, Regional Medical Program and Denver Department of Health and Hospitals

1970 Member, President's Commission on Environmental Studies of the University of Colorado

1970-71 Member, Committee on Communicable Disease, Colorado Medical Society

1970-75 Member, University of Colorado Environmental Council

1970-75 Member, Environmental Council, University of Colorado

1973-80 Member, Governor's Scientific Advisory Council, Colorado

1974 Member, Eisenhower Tunnel Carbon Monoxide Standards Advisory Committee

1974-75 Member, Governor Lamm and Congressman Wirth's Task Force on Rocky Flats Plutonium Plant

1976 Member, Governor's Task Force on Uranium Enrichment Plant

1976-79 Commissioner, Air Pollution Control Commission of Colorado

1977 Member, Governor's Blue Ribbon Task Force on Transportation

Extra-Curricular/Health-Related Activities, Continued

1977-78 Member of AAAS Seminar Group on Air Pollution

1978- Member of Governor's Task Force on Health Effects of Air Pollution

1978- Member, Air Quality Policy Committee, Denver Regional Council of Governments

1978- Board Member, ROMCOE Center for Environmental Problem Solving

1978- Board Member, Mountain Bicyclists Association

1978- Board Member, Colorado Coalition for Full Employment

1979- Member, American Friends Service Committee Advisory Group on Rocky Flats/Nuclear Weapons Project

1980- Coordinator of Ethics Seminars at University Health Sciences Center

National:

1965-75 Member, National Committee on Indian Health of the Association on American Indian Affairs

1967-69 Member, Comprehensive Health Planning, Training and Studies Review Committee for U. S. Department of Health, Education and Welfare, Office of Comprehensive Health Planning

1971-73 Member, National Medical Committee, Planned Parenthood/World Population

1972-73 Executive Committee Member, American Association of Planned Parenthood Physicians

1972-73 President, American Association of Planned Parenthood Physicians

1972-73 Board Member, Planned Parenthood Federation of America

1978- Consultant, National Institute of Occupational Health and Safety on Naval Shipyards/Nuclear Submarine Studies

1981- Advisory Council of Coalition for Responsible Genetic Research

1982- Member, Advisory Group on Three-Mile-Island Nuclear Accident, Public Health Fund

International:

1968-70 American Friends Service Committee, Division of International Services, Family Planning Committee Member and Member of Working Party to prepare report, "Who Shall Live? Man's Control over Birth and Death."

Extra-Curricular/Health-Related Activities, Continued

Member, International Solar Energy Society (since 1958)

1970 Member, WHO Scientific Group on Advances in Research (Clinical Experience with Methods of Fertility Regulation) Geneva

1979- Member, Physicians for Social Responsibility

1980 Medical Consultant to Executive Council on Foreign Diplomats
Grand Canyon Conference (July 1980)

PUBLICATIONS BY: JOHN CANDLER COBB, M.D., M.P.H.

"The Detection of Beta-Radiation by Photographic Film," with A. K. Solomon, Review of Scientific Instruments, Vol. 19, pp: 414-447, July, 1948

"Radioautograph Technique With Carbon 14," with A. K. Solomon and A. M. MacDonald, Science, Vol. 107, pp: 550-552, May, 1948

"Stripping Film Technic for Radioautographs," with A. M. MacDonald, A. K. Solomon and D. Steinberg, Proc. Soc. Exper. Biol. and Med., Vol. 72, pp: 117-121, October, 1949

"Paroxysmal Fussing in Infancy, Sometimes Called 'Colic'," with Morris Wessel, Edith B. Jackson, George S. Harris, Jr., and Ann C. Detwiler, New Haven, Pediatrics, Vol. 14, No. 5, pp:421-435, 1954

"Family Tension as a Cause of Colic in Infants," American Academy of Pediatrics Proceedings, Colic in Infants, Pediatrics, Vol. 18, No. 5, pp: 835-836, November, 1956

"Navajo Child Health Level Mirrors Tribe Future," Public Health Reports, Vol. 73, No. 3, March, 1958 (abstract)

"Precocity of African Children," Pediatrics, Vol. 21, pp: 867, 1958 (letter)

Emotional Problems of Indian Students in Boarding Schools, Report of Seminar Sponsored by U.S.P.H.S., Division of Indian Health, N.I.M.H., and New Mexico Department of Public Health, Published by New Mexico Department of Public Health, Albuquerque, N. M., 66 pages, 1960 (J.C. Cobb - editor)

"Trachoma Among Southwestern Indians," with C. R. Dawson, J.A.M.A., Vol. 175, No. 5, Feb. 4, 1961

"Aspectos de Salud Publica de la Mortalidad Infantil," with R. F. Goddard and S. J. Leland, Boletin de la Oficina Sanitaria Panamericana, Vol. 51, pp: 130-144, August, 1961

"Our 'Vanishing Americans'," Harvard Medical Alumni Bulletin, Summer, 1961

"Some Practical Considerations of Economy and Efficiency in Infant Feeding," Report of the Joint Committee on Economy and Efficiency in the Preparation of Infant Feeding, (J. C. Cobb - member), American Public Health Association, A.J.P.H., Vol. 52, pp:125-142, 1962

"The Population Problem and Family Planning in Pakistan," with H. M. Raulet, Journal of the Pakistan Academy for Village Development, Comilla, Vol. 3, No. 1, pp: 1-11, July, 1962

"A Preliminary Report on the Use of Oral Contraceptive Pills Synchronized With the Phases of the Moon," with N. A. Shah, published in Report of I.P.P.F. Conference, Singapore, 1963, Excerpta Medica, Amsterdam, International Congress Series No. 72, pp: 394-398, 1964

PUBLICATIONS BY: JOHN CANDLER COBB, M.D., M.P.H.

"Some Problems of Demographic Measurement in Family Planning Research in the Punjab," with J.F. Kantner, Population Index, Vol. 29, p. 233

"The Social Implications of Genetics with Special Reference to Pakistan," Mother and Child, Vol. 2, No. 1, pp:5-9, Jan. 1964

Pakistan: "The Medical Social Research Project at Lulliani," Studies in Family Planning, No. 8, pp:11-16, October, 1965

"Oral Contraceptive Program Synchronized With Moon Phase," Fertility and Sterility, Vol. 17, pp:559-567, July-August, 1966

"Technology is Not Magic," Harvard Medical Alumni Bulletin, pp:8-9, Spring, 1967

"Abortions in Colorado 1967-1969," Advances in Planned Parenthood, Vol. V, Excerpta Medica International Congress Series No. 207, pp:186-189, 1970

Who Shall Live? Man's Control Over Birth and Death, A report (with others of the working party) to the American Friends Service Committee, Hill and Wang, 1970 - also translated into Spanish, "Quienes Viviran?" and published in Latin America, 1972

Methods of Fertility Regulation: Advances in Research and Clinical Experience, WHO Technical Report Series No. 473, 1971 (with other members of scientific group convened in Geneva, December, 1970)

Report on the Development of Education and Information Materials on Family Health, World Health Organization, WPRO, Manila, 1972

"Non-procreative Sexuality as an Alternative to Contraception," Advances in Planned Parenthood, Vol. VIII, Excerpta Medica International Congress Series No. 271, pp:67-74, 1973

Report on the Regional Seminar on the Role of Health Education in Family Planning, World Health Organization, WPRO, Manila, 1973

"Standards for Air Pollutants for Denver" and "Health Effects of Carbon Monoxide and Photochemical Oxidant Air Pollution in Denver" - Chapters in monograph, Carbon Monoxide and the People of Denver, Miriam Orleans and Gilbert White, Eds. The University of Colorado IBS publication, 1974.

Chapter on "Preventive Medicine and Public Health" (with Lee Kaiser) in Interdisciplinary Environmental Approaches, Utton and Henning Eds., Educational Media Press, California, 1974

Report and Recommendations of the Eisenhower Tunnel Carbon Monoxide Standards Advisory Committee, Colorado Department of Health, August 28, 1974

Medical Committee Report (with Arthur Robinson and Edward Gillette) of the Lamm-Wirth Task Force on Rocky Flats Plutonium Plant Preliminary Report, Colorado State Department of Health, February 10, 1975

PUBLICATIONS BY: JOHN CANDLER COBB, M.D., M.P.H.

Final Report - Lamm-Wirth Task Force on Rocky Flats, October 1, 1975

"Recruiting The Uncommitted Leader for Family Planning" with Moulding, T.S. & Cortese, C.F. The Mount Sinai Journal of Medicine 42, p. 308, 1975 (Alan Guttmacher Memorial Issue)

"Limits to Human Adaptability" published in The Future of Human Settlements in the Rocky Mountain West Vail Symposium/Six - T.J. Minger Ed., 1977.

"The Suntrap Insolator/Insulator" Proceedings of the Solar Cooling and Heating Forum, Univ. of Miami, 13 December 1976, T.N. Veziroglu, Ed., 1978.

Participation in Governor's Task Force on the Health Effects of Air Pollution in Colorado, R. Mitchell, Chairman - Report issued July 1978. Modified version published by Mitchell et al, J.A.M.A. 242, p. 1163-8, 1979

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Report to EPA, not yet cleared for publication, "Plutonium in Human Tissues Related to Smoking, Age, Residence near Rocky Flats and Eastern Colorado." (This is the report of our research work 1975-1982.)

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BEFORE THE
UNITED STATES NUCLEAR REGULATORY COMMISSION
ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
U.S. DEPARTMENT OF ENERGY PROJECT MANAGEMENT CORPORATION TENNESSEE VALLEY AUTHORITY	)	Docket No. 50-537
(Clinch River Breeder Reactor)	)	

TESTIMONY OF DR. KARL Z. MORGAN

My name is Karl Ziegler Morgan. I reside at 1984 Castleway Drive, Atlanta, Georgia 30345.

I am presently engaged in consulting on matters of radiation protection with a number of organizations. In this case, however, I will accept no consulting fee and am testifying in what I consider to be the public interest.

I was Director of the Health Physics Division, Oak Ridge National Laboratory (ORNL) from 1943 to 1972. I have many years of experience in areas of health physics, radiation protection, instrumentation, internal dose, radiation standards, reduction of exposures from LWR operations, and the effects of low-level radiation. I was one of the group of the first five health physicists at the Univerity of Chicago early in 1943, and some years later the first President of both the

Health Physics Society and the International Radiation Protection Association. I was editor-in-chief of the Journal of Health Physics from its beginning until 1977. I was chairman of the Internal Dose Committee of both the National Committee on Radiation Protection (NCRP) and the International Commission on Radiological Protection (ICRP) for a quarter of a century. It was during this period that NCRP 69 and ICRP 2 were prepared -- much of them written by me. These publications give values of $(MPC)_a$ and $(MPC)_w$ for all the principal radionuclides and these values serve as the basis of the MPC values found in 10 CFR, Part 20, of the NRC Regulations. I was a professor in the School of Nuclear Engineering and Health Physics at Georgia Institute of Technology from 1972 to 1982. I have had an interest in both burner and breeder reactors for many years. In fact, I submitted a paper for presentation at a conference in ~~Nuremberg~~ Neuherberg, Germany, shortly before leaving ORNL, showing some of the health physics advantages of the molten salt thermal breeder over the liquid metal fast breeder (LMFBR). However, this portion of my paper was censored and deleted by ORNL management while I was in transit to Germany.

The purpose of this testimony is to offer evidence with regard to Intervenors' Contentions 1 and 2. Let me begin by stating that I have long been a supporter of nuclear power technology where it can be developed safely. Unfortunately,

this has not always been the case. In this regard, my support for nuclear power does not imply that I am in favor of development of LMFBRs, including the construction of the Clinch River Breeder Reactor (CRBR).

I believe there are other breeder reactor concepts which I am told by my associates at Georgia Tech would be more efficient with shorter doubling times and higher breeding ratios, which I believe would be safer and pose less proliferation risk and which could advance us much further beyond the French Phenix and Super Phenix breeder reactors.

I have examined the March 4, 1977, Site Suitability Report (1977 SSR) on the CRBR and the June 1982 Revision to the Site Suitability Report, NUREG-0786 (1982 SSR), both prepared by the Nuclear Regulatory Commission (NRC) staff (henceforth referred to as "Staff"), regarding the evaluation by the Staff of the site suitability source term (SSST) dose consequences for purposes of determining whether the requirements set forth in 10 CFR Part 100 of the NRC's regulations are met for the CRBR site. I am also familiar with the requirements of 10 CFR Part 100. Based on my analyses of these documents, my background, and my experience, it is my conclusion that the requirements of 10 CFR Part 100 have not been met and that the CRBR site is not suitable for a LMFBR of the general size and type as the CRBR.

Regarding Contention 1, I am of the firm belief that a core disruptive accident is a credible occurrence at the CRBR and that it should be part of the design basis for LMFBRs of the general size and type as the CRBR. Regarding Contention 2, I disagree with Staff's analysis in three principal areas: (a) their choice of and methodology for choosing the site suitability source term (SSST), (b) their calculation of the internal dose to critical organs resulting from this postulated source term, and (c) their selection of appropriate dose guidelines for various organ doses under 10 CFR 100. These issues will be treated separately below. In addition, there may be errors in the assumptions used by Staff in the pathway analysis, that is, in calculating the transport of radioactivity from the reactor containment to exposed individuals. Unfortunately, the 1977 SSR and the 1982 SSR are so poorly documented that one cannot reproduce the Staff's results to assess whether the calculations were performed accurately and with appropriately conservative assumptions. As a matter of science, I do not believe that the Atomic Safety and Licensing Board or the public should rely on estimates of dose and conclusions based on analyses that are not adequately documented and that cannot be readily reproduced.

I. Contention 1:
Core Disruptive Accidents Should Be Considered Design Basis Accidents

I will begin by addressing Contention 1(a), and explain why it is my considered judgment that CDAs are credible and should be included in the design basis for the CRBR. Core meltdown and nuclear explosions in LMFBRs have been considered credible accidents by myself and many others in the nuclear community ever since the Manhattan Project days when people first began to consider the possibility of breeder reactors. It is because we considered these nuclear explosions in breeders credible and because of the very high risk of plutonium releases from such accidents that many of my colleagues and I at ORNL strongly favored development of the molten salt breeder reactor over the LMFBR. Considering the accidents that have occurred already at the Experimental Breeder Reactor-I (EBR-I), Enrico Fermi Atomic Plant (Fermi-I), and the human and design errors associated with the accident at Three Mile Island Unit 2 (TMI-2), it is difficult to understand how any objective analyst could conclude that a core meltdown or nuclear explosion in a reactor similar to the CRBR is not credible. Although I favor research on advanced breeder and converter reactor systems, I am very uneasy about the CRBR and its inventory of transuranium radionuclides. As a taxpayer, I have been concerned with the escalating cost of this "Noah's Ark" on the banks of the Clinch River. But I have an even more

serious concern, I do not believe my many friends in Oak Ridge and neighboring communities have been given adequate assurance that there have been no serious compromises in safety to reduce the steeply rising cost.

II. Contention 2:

A. The Site Suitability Source Term is Inadequate

Under 10 CFR §100.11(a), the assumed fission product release, or SSST, should be based upon "a major accident, ... that would result in potential hazards not exceeded by those from any accident considered credible."

The Staff has chosen a source term that involves the release of only 1% of the plutonium and solid fission products. This presumably is based on Staff's position that a core meltdown and possible nuclear explosion is not a credible accident in an LMFBR. As I explained in my testimony on Contention 1 above, I consider this position indefensible.

The Staff's source term is also inconsistent with the source terms postulated for early fast reactors. In assessing the hazards associated with siting early fast reactors, a severe nuclear explosion was generally hypothesized and it was assumed that some one-half or all of the plutonium would be released from the reactor core.* This is consistent with the

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*/ For SEFOR, all plutonium and fission products were assumed to be released.

original intent behind 10 CFR 100, i.e., hypothesizing the maximum possible accident (usually considered incredible).

As can be seen from Table IV in the 1982 SSR (p. III-11), increasing the plutonium fraction by a factor of 50, without changing any other assumption, would result in bone and lung doses, for which the plutonium isotopes are likely to be the principal contributors, which far exceed even the guideline values used by the Staff for these organs. As will be indicated below, if the Staff were to correct other errors in their SSST dose calculations, the bone surface dose limits would be exceeded even without increasing the SSST.

Regarding Intervenors' Contention 2(b), I agree that the radiological source term analysis should not only be based on the assumption that CDAs are credible accidents, but should also place an upper bound on the explosive potential for a CDA and should then derive a conservative estimate of the fission product release from such an accident. It is not enough for the Staff to postulate a CDA and then use "best estimates" to determine the source term resulting from such an accident. The Staff has had so little experience to date in licensing LMFBRs with core explosive potential -- in fact, none with respect to a reactor of the general size and type as CRBR -- that it must apply conservatisms at each step of the analysis. 10 CFR § 100.2 specifies that "for reactors that are novel in design and unproven as prototypes, or pilot plants, it is expected that

these basic criteria will be applied in a manner that takes into account the lack of experience." In particular, the Staff must recognize that a core disruptive accident in an LMFBR provides a potential mechanism for volatizing and releasing substantially larger fractions of plutonium from the core than in an LWR, challenging the secondary containment due to missiles and heat and pressure generated by burning sodium, and consequently potentially resulting in substantially larger offsite doses and ground contamination by plutonium and other transuranium elements.

B. Staff Has Not Correctly Performed or Adequately Documented the Dose Consequences in the SSST Analysis.

The Staff has calculated the whole body, thyroid, lung, and bone doses at the exclusion area and low population zone boundaries (1982 SSR, Table IV, p. III-11) for purposes of comparing these against dose guidelines as required under 10 CFR Part 100. These calculations are in error in at least the following respects:

a) failure to consider the dose "from the entire passage of the cloud;"

b) failure to use conservative values for the plutonium isotopic concentrations;

c) failure to consider all isotopes of interest;

d) failure to use current dosimetric and metabolic models;

e) failure to consider all pathways;

f) failure to properly calculate the bone (and bone surface) dose.

In addition, the calculations are not adequately documented and consequently one cannot otherwise determine their validity. I will address each of these issues separately below.

a) The SSST analysis fails to consider the dose from the entire passage of the radioactive cloud.

10 CFR §100.11(a)(2) requires that the low population zone (LPZ) outer boundary dose be calculated for the radioactive cloud "during the entire period of its passage." The Staff's LPZ dose calculations were truncated at the end of 720 hours (30 days).*

The Staff, in response to NRDC's Interrogatories, has indicated that

> In the case of LWRs, the dose contribution beyond 30 days is negligible. However, in the case of CRBR, the doses were found to be significantly larger for a puff release at the end of 30 days (considered to be the worse case condition), than doses calculated for the first 30 days.**

Without correcting any other errors in Staff's SSST dose calculations, the LPZ boundary doses would be increased as indicated in Table 1 below:

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*/ This is clear from a comparison of Staff's August 5, 1982, response to Interrogatory 33 (NRC Staff's Supplemental Answers to NRDC's Twenty-Sixth Set, p. 14) against the LPZ doses presented in Table IV of the Revised SSR (p. III-11).

**/ Staff's Response to Interrogatory 33 in NRC Staff's Supplemental Answers to NRDC's Twenty-Sixth Set, August 5, 1982, p. 14.

Table 1

Organ	LPZ dose(rem) (0-30 days)	LPZ dose(rem) (0-30 days plus Puff Release)
Whole body	0.34	0.47
Thyroid	6.8	12
Lung	0.37	1.6
Bone	9	38
Bone Marrow	2.1	9.1
Bone Surface	27	115
Liver	0.98	4.1
Skin	1.3	1.5

The values in the right-hand column (0-30 day plus puff) are based on an appropriately conservative treatment of the requirement to consider the entire passage of the cloud, whereas the values on the left (0-30 day truncated) should be rejected. Errors in calculating the values on the right still must be corrected further as indicated below.

b) The SSST analysis fails to utilize conservative values for the plutonium isotopic concentrations.

In calculating the SSST dose at the exclusion and LPZ boundaries, the Staff assumed that the plutonium had the following isotopic concentrations (weight %):*

1% Pu-238
74% Pu-239
20% Pu-240
5% Pu-241
0% Pu-242

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*/ Staff response to Interrogatory 23 in NRC Staff's Answers to NRDC's Twenty-Sixth Set, July 27, 1982, p. 23.

The isotopic concentration of Pu-238 and Pu-241 are controlling in terms of bone dose as can be seen from the Hazard Index calculated in Table 2 below.

Table 2

Isotope (Pu-i)	Weight%	Weight % Normalized to Pu-239	Curies/ gram	(A) Ci Pu-i/ Ci Pu-239	(B) Bone Surf. Dose Norm. to Dose Due to Pu-239	(A)x(B) Hazard Index
Pu-238	1	0.0135	16	3.5	0.81	2.8
Pu-239	74	1	0.062	1	1	1
Pu-240	20	0.27	0.22	0.96	1	0.96
Pu-241	5	0.068	120	130	0.019	2.35

This Hazard Index, represented by the product:

$$(H.I.)_i = \frac{\text{Ci Pu-i}}{\text{Ci Pu-239}} \times \frac{\text{Bone Surface dose/Ci Pu-i}}{\text{Bone Surface dose/Ci Pu-239}}$$

was calculated using the Staff's assumptions for the plutonium isotopic concentrations (column 2) and the Staff's assumptions for the bone surface dose conversion factors normalized to the Pu-239 values (column 6). The latter were provided as computer printout (NRC BATHSYS 1.89 DGC ECLIPSE S/230 07/23/82, 11:43 AM) supplied to NRDC (for inspection and copying) by the Staff in response to Interrogatory 1 in NRC Staff's Supplemental Answers to NRDC's Twenty-Sixth Set, Aug. 5, 1982, p. 3. While the Hazard Indices would change somewhat if alternate isotopic concentrations and alternate dose conversion factors were used, it can be seen from the values calculated above, that the

principal bone dose contribution (approximately 72%* in this case) is due to the contributions from Pu-238 and Pu-241.

Consequently, Staff's assumed plutonium isotopic ratios are not conservative if the CRBR will be operated using plutonium with higher concentrations of Pu-238 and Pu-241 during its projected 30-year lifetime.

Applicants have indicated that the initial core of the CRBR will be fueled with fuel-grade plutonium with estimated EOEC** fuel concentrations of 0.15% Pu-238, 79.6% Pu-239, 17.4% Pu-240, 0.34% Pu-241 (PSAR, p. 15.A-11). Staff claims its choice of Pu isotopic concentrations is "reasonably conservative in light of possible future use of reactor-grade plutonium in CRBRP fuel; it is similar in composition to some of the commercial LWR spent fuel now in storage".*** While Staff's choice of Pu isotopic concentrations is more conservative than Applicants', neither is conservative compared to high burnup LWR fuel, e.g., burnup on the order of 33,000 Mw-d/MT (or higher). This can be seen from the columns

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*/ (2.8 + 2.35)/(2.8 + 1.0 + 0.96 + 2.35) = 0.72. In response to Interrogatory 37 of NRC Staff's Supplemental Answers to NRDC's Twenty-Sixth Set, Aug. 5, 1982, p. 15, Staff indicates that the Bone Surface dose is due almost entirely to plutonium.

**/ End of Equilibrium Cycle.

***/ Response to Interrogatory 24, NRC Staff's Answers to NRDC's 26th Set, July 27, 1982, p. 23 (emphasis supplied).

In this case, the hazard index after two four-year recycles is no longer 2.8 for Plutonium-238, but is now 34; and the index for Plutonium-241 has risen from 2.35 to 20.6. That is, if an accident in the future releases breeder fuel, the cancer risk from Plutonium is 55 times greater from Plutonium-238, plus Plutonium-241, than from Plutonium-239, and 50 times greater than the NRC Staff assumed.

labeled 1-4 in Table 3 below:*

Table 3

CALCULATED PLUTONIUM COMPOSITION - PERCENT

	1 Pu Recovered From Spent U Fuel	2 Pu After One 4-year Recycle	3 Pu After Two 4-year Recycles	4 Pu Recycle Model BWR
^{238}Pu	1.9	3.46	4.87	3.4
^{239}Pu	57.9	38.2	29.4	41.7
^{240}Pu	24.7	29.4	33.5	29.2
^{241}Pu	11.0	17.2	17.4	15.2
^{242}Pu	4.4	11.7	14.9	10.4
Pu_f*	68.9	55.4	46.8	57.0

*$Pu_f = {}^{239}Pu + {}^{241}Pu$

Furthermore, it should be noted from Table 3 above that, as the MOX fuel is recycled, its fissile content is reduced (~~19%~~ 79% fissile assumed by the NRC compared with 46.8% in column 3). This Pu_f means more plutonium will be contained in the fuel loading of the CRBR as the number of recycles increases.** Accounting for this additional factor will further increase the assumed Pu release under the SSST analysis, and further increase the bone surface dose.

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*/ This table of Pu isotopic concentrations is taken from USNRC, "Final Generic Environmental Statement on the Use of Recycle Plutonium in Mixed Oxide Fuel in Light Water Cooled Reactors," NUREG-0002, Vol. 3, p. IV C-70. Similar values are reported by Cullingford, Hatice S., "Alternatives to Proposed Replacement Production Reactors," LANL, LA-8867, June 1981, p. 6.

**/ While I recognize that these weight percents do not reflect actual differences in fuel loadings, correcting for differences in the fission cross sections is not likely to change the conclusion.

Since DOE plans to construct a Developmental Reprocessing Plant (DRP) for the purpose of reprocessing and recycling CRBRP fuel (USNRC, Draft Supplement to FES CRBR, NUREG-0139, Supplement No. 1, p. D-11), it is appropriate to assume that CRBR will be fueled with recycled (LWR or LMFBR) MOX with the higher concentrations of Pu-238 and Pu-241 comparable to those in columns 3 in the table above and that the curie levels for these isotopes should be further increased because of the lower fissile content. The problem is further compounded because the hazard of plutonium-238 relative to plutonium-239 under certain circumstances is several orders of magnitude greater than unity (see K.Z. Morgan, W.S. Snyder, and M.R. Ford, Health Physics 10, 151-169 (1964)).

More precise estimates of the plutonium isotopic concentrations of the CRBR plutonium fuel during the course of its 30-year lifetime cannot be presented because Intervenors were denied discovery on issues related to meeting the fuel requirements of the CRBR and the environment and safety implications associated with the origin of CRBR fuel. Board's ruling of April 6, 1982, and April 14, 1982, Order. Nevertheless, it is clear that when the Staff's SSST LPZ bone surface dose calculation is corrected to reflect both (i) the requirements to consider the entire passage of the cloud (discussed under (a) above) and (ii) the more conservative of the Pu isotopic concentrations in CRBR

fuel that can be expected during the 30-year lifetime of the CRBR, the LPZ bone surface dose would exceed by a wide margin even the very high 150 rem guideline value favored by the Staff. As such, correcting these two mistakes alone would make the CRBR site unsuitable as judged by the requirements of 10 CFR Part 100.

c) The SSST analysis fails to consider all isotopes of interest.

In the NRC Staff's SSST analysis consideration is given to the dose contributions of only the following isotopes:

I-131	Kr-83m	Xe-131m	Pu-238
I-132	Kr-85m	Xe-133m	Pu-239
I-133	Kr-85	Xe-133	Pu-239
I-134	Kr-87	Xe-135m	Pu-240
I-135	Kr-88	Xe-135	Pu-241
I-136	Kr-89	Xe-137	
		Xe-138	

The Staff has not made an adequate showing that other isotopes do not also contribute significantly to the dose. The Staff claims

> It was determined that the transuranic elements other than plutonium contribute about 3% of the total dose for any one organ (the primary organs affected being the lung and bone). The analysis was done by calculating the dose with and without transuranic elements.*

*/ Response to Interrogatory 31, NRC Staff's Answers to NRDC's 26th Set of Interrogatories, July 27, 1982, p. 27.

The Staff, however, has not made available the analysis that purports to support this claim.* More importantly, since the Staff SSST analysis is based on outdated dosimetric models (see discussion under (d) below), any conclusion in this regard drawn from use of these older models is not reliable.

d) The SSST analysis was not performed using current dosimetric and metabolic models.

The Staff used the same bone and lung dose commitment factors (DCF) for plutonium isotopes in the SSST analysis that Staff was using in 1976.** The Staff states that:

> For the significant nuclides in the pathways considered in the SSR the dose commitment factors (DCF) were computed using one of two models. For thyroid inhalation the DCFs in rems per curie were computed by the methodology described in a USAEC document TID 14844, Calculation of Distance Factors for Power and Test Reactor Sites. Whole body immersion DCF's in rems per sec/curie per cubic meter and other inhalation DCF's were computed with the model detailed in a USNRC document NUREG-0172, Age Specific Radiation Dose Commitment Factors for a One Year Chronic Intake. Whole body inhalation DCF's were not used.

Response to IV.22 and IV-36, NRC Staff's Supplemental Answers to NRDC's 26th Set, Aug. 5, 1982, p. 12.

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*/ The Staff claims here to have performed two analyses, one complete and one incomplete. It is not apparent to me why if the more complete analysis was performed it was not reported instead of the incomplete analysis.

**/ As evidenced by comparing the computer printout (NRC BATHSYS 1.89 DGC ECLIPSE S/230 07/23/82, 11:43 AM) against "F" factors supplied as enclosure to letter from Barry H. Smith, NRC, to Anthony Z. Roisman, Sept. 16, 1976.

The second of these two references, NUREG-0172 (p. 16), states that:

> The dose models employed in the derivation of these factors are based primarily upon a 1959 report of Committee 2 of the International Commission on Radiological Protection (ICRP) as updated by ICRP reports 6 and 10. There are ongoing efforts by the NRC staff to further refine these dose conversion factors and to update them using the new physiological and anatomical data in ICRP Report No. 23 and more realistic methods of considering the radiation doses to other target organs from gamma photon emitting radionuclides located in a specific source organ. These modified dose conversion factors will be published as they become available. (Footnotes omitted)

First, the earlier ICRP models referred to above have been superseded by newer dosimetric and metabolic models employed in ICRP 23 and 30. Using the newer ICRP 23 and 30 models, the lung, bone, and liver doses from plutonium (and other transuranic elements) can be expected to differ (in some cases significantly) from the doses calculated using ICRP-2 methodology. EPA, for example, has indicated (USEPA, "Proposed Federal Radiation Protection Guidance for Occupational Exposure, January 16, 1981, p. B-4) that the $(MPC)_a$ for Pu-239 is lowered by a factor of 10 for Class Y compounds and by a factor of 2 for Class W compounds as indicated below:

Table 4

Nuclide/Class		$(MPC)_a$ (mCi/l) Using ICRP-2	Using ICRP-23 & 30
Pu-238	W	2(-12)* bone	2(-12) bone surface
	Y	3(-11) lung	4(-12) bone surface
Pu-239	W	2(-12) bone	1(-12) bone surface
	Y	4(-11) lung	4(-12) bone surface
Am-241	W	6(-12) bone	1(-12) bone surface

These data indicate that using the newer models could increase the dose due to a particular plutonium (or other transuranic) isotope by a factor between 0 to 10 depending on the particular isotope and chemical form. Without correcting any other errors in the Staff's SSST analysis, the choice of models could affect whether the CRBR is suitable or not under 10 CFR Part 100 requirements.

e) The SSST analysis fails to consider all pathways of interest.

The Staff utilized a set of dose conversion factors (DCFs) for isotopes of I, Kr, Xe, and Pu as input assumptions in their TACT code SSST analysis. These DCFs are presented in the TACT code output (see printout identified as NRC BATHSYS 1.89 DGC ECLIPSE S/230 07/23/82). I will examine Staff's plutonium lung and bone dose DCFs as an example (i) to demonstrate that the

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*/ 2(-12) reads as 2×10^{-12}.

Staff's DCFs are not conservative, (ii) to support the evidence presented under (d) above that current models were not employed, and (iii) to provide evidence that important pathways were not treated. With regard to the last, it should be noted that 10 CFR 100(a)(1) and (2) require the calculation of the total dose, not a partial dose from selective pathways.

For Pu isotopes Staff utilized:

Table 5

Isotope	Staff DCFs (rems/curie) Lung	Bone
Pu-238	1.83 (8)	2.74 (9)
Pu-239	1.72 (8)	3.19 (9)
Pu-240	1.72 (8)	3.18 (9)
Pu-241	1.52 (5)	6.41 (7)

ORNL tabulated a set of DCFs which included effects of plume submersion, inhalation (direct and via resuspension), dietary intake, and fallout irradiation (REMPERSIGH MANUAL, EW CRESS, May 1964). While these values were reported in units of rem/Ci-sec-m^{-3}, the inhalation values can be converted to rem/curie by dividing by 2.3148 x 10^{-4} m^3/sec, the breathing rate assumed for the standard man (20 m^3/day). I have done this in Table 6 below.

Table 6

	ORNL DCFs (rem/curie) Initial Inhalation		Inhalation and Resuspension	
Isotope	Lung	Bone	Lung	Bone
Pu-238	1.9 (8)	5.7 (9)	3.0 (8)	9.1 (9)
Pu-239	1.8 (8)	6.6 (9)	2.8 (8)	1.1 (10)
Pu-240	1.8 (8)	6.6 (9)	2.8 (8)	1.1 (10)
Pu-241	1.7 (5)	1.2 (8)	2.6 (5)	2.0 (8)

A comparison of ORNL's DCFs in Table 6 against those used by the Staff in Table 5 suggests:

1) Staff failed to consider inhalation via resuspension, an important pathway.* ORNL's lung DCFs (for initial inhalation only) are almost identical to NRC Staff's. Including the "inhalation via resuspension" pathway would increase the lung, liver, and bone doses by an additional 60%, more than enough to exceed the Staff proposed bone surface dose guideline of 150 rem at the CP stage if the dose were also calculated for the entire passage of the cloud (115 x 1.6 = 184 rem). Thus, the site is unsuitable, correcting no other errors.

2) There is a further discrepancy of a factor of 2 between the two DCFs for bone (and therefore bone surface), with the Staff's values being the less conservative ones. This discrepancy cannot be explained due to inadequate documentation by the Staff (and ORNL) of their bases for their respective choice of values.

3) Since ORNL's calculations were performed in 1974, the similarity of the ORNL and Staff DCFs for lung (inhalation only) provides further confirmation that the Staff dosimetric and metabolic models are not current.

For the foregoing reasons, the Staff's choice of DCFs used in the SSST analysis should be rejected as nonconservative and should be properly documented before they are accepted.

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*/ Other pathways that should be examined are exposure from fallout and dietary intake.

C. Staff Has Failed to Select Conservative 10 CFR Part 100 Dose Guidelines for Lung and Bone

The Staff has failed to demonstrate that unplanned releases of transuranic elements into the general environment during accidents can be expected to result in radiation levels that are very low and well below the guidelines set forth by EPA. The September 1977 EPA summary report, "Proposed Guidance on Dose Limits for Persons Exposed to Transuranium Elements in the General Environment" states (pp. 20,21) that the alpha dose to the critical segment of the exposed population as a result of exposure to transuranic elements should not exceed either one millirad per year to the pulmonary lung or three millirad per year to the bone. With regard to "possible future unplanned releases," e.g., in areas neighboring a newly constructed nuclear power plant, control measures, such as those claimed for the CRBR, should assure that exposures will be well below the one millirad per year to the lung or three millirad per year to the bone.

It is clear that the intake of plutonium by members of the public would have to be exceedingly low to comply with this guideline (e.g., a person must inhale less than 27 picacuries of Pu-239). It appears to be the intention of the Staff to assure noncompliance with this EPA guideline.

There is strong evidence that the present levels set by the Staff as guides or limits of exposure to plutonium are nonconservative. I believe the maximum permissible body burden

of 0.04 microcuries (corresponding to an average bone dose rate of 30 rems per year for the remaining life of the radiation worker) as a Pu-239 limit for the occupational worker is too high by several orders of magnitude. Our present plutonium levels for members of the public are related to or derived from the occupational exposure limits, so they are proportionately high. The value of 0.04 microcuries of Pu-239 is derived by comparison with Ra-226, which becomes fairly uniformly buried in the bone matrix and delivers an average dose rate of 30 rem year to the skeleton of a 70-kg radiation worker. Plutonium, however, is a bone surface seeker and accumulates primarily in the endosteal and perosteal surfaces of the tubercular bone. This makes plutonium much more harmful per rad than radium-226 because solid tumors (bone cancers) tend to originate in this thin layer of tissue, and this tissue of the inner walls of the tubercular cavities encapsulates the active (red) bone marrow where most forms of radiation-induced leukemia originate.

Studies of Mays and Spiess have shown that, curie for curie, Ra-224 is more carcinogenic than Ra-226 and that the human cancer incidence increases as the dose is protracted (just the opposite of effects of protraction of Ra-226). This difference is due to the fact that, unlike Ra-226, the short-lived Ra-224 does not have time to become buried in the cortical bone, so it delivers its dose to the endosteal and periosteal bone surfaces, as does plutonium and the transplutonics. Thus, the 0.04 microcuries of Pu-239 delivers

much more than 30 rem/year to bone surfaces and is far more harmful than the 30 rem/year delivered to the 7 kg of the entire bone by the 0.1 microcuries of Ra-226 standard on which all permissible levels of exposure to bone-seeking radionuclides are directly referenced. The dose to a population from plutonium contamination in the environment, like that from Ra-224, is delivered to what is man's carcinogenic "Achilles heel," and the resuspension of plutonium in the air and its recycling for many generations in the environment delivers a protracted bone surface dose which, as for Ra-224, is much more harmful per curie, or per rad, than were its dose delivered over a short period of time.

My article in the American Journal of Industrial Hygiene (August 1975) gave four additional reasons why the 0.04 microcurie level for Pu-239 is high, which add up to a required reduction factor of 240. Although there have been criticisms of these four factors, I am not convinced any of them are substantial.

The factor that has been most severely criticized is the factor of four -- based on the study of Metivier, et al., -- which showed baboons are four times more sensitive to radiation-induced lung cancer than dogs, and my belief that the baboon is a closer relative to man than the dog. I have been working in the field of ionizing radiation for over 50 years, and, although I recognize the necessity in some cases to use animal data to set our radiation standards, I am strongly

convinced that we must use human data (or at least primate data) wherever possible. This is why I am uneasy with the rather cavalier attitude of the Staff in turning away from the radium standard on which we have a vast amount of human data relating to the 0.1 microcuries of radium-226 hallmark reference, on which our ICRP 2 and NRC plutonium and transplutonic permissible exposure levels are based.

Finally, I am concerned that the Staff has selected to apply only a factor of two to the bone surface and lung dose (i.e., 300/2 = 150 rem and 75/2 = 35 rem, respectively) to an assumed individual at the exclusion area boundary and outer boundary of the LPZ to account for uncertainties, a few of which are discussed above. The Staff's Supplemental answers to NRDC's Twenty-Sixth Set of Interrogatories (8/5/82) at p. 19 stated that a factor of 10 was applicable in 1977, but the Staff no longer believes this to be the case in 1982. I believe the uncertainties are just as high or higher today, and in any case exceed one order of magnitude in part for the reasons given above. Of course, it goes without saying that I believe dose levels of 150 rem to bone and 35 rem to lung would result in severely serious consequences and are far beyond acceptable levels.

I am presenting these observations and plan to defend them in a public hearing as a public service without remuneration for my time and trouble. I respectfully request that the Licensing Board in this hearing will give due consideration to these comments.

BEFORE THE
UNITED STATES NUCLEAR REGULATORY COMMISSION
ATOMIC SAFETY AND LICENSING BOARD

In The Matter Of	
UNITED STATES DEPARTMENT OF ENERGY PROJECT MANAGEMENT CORPORATION TENNESSEE VALLEY AUTHORITY	Docket No. 50-537
(Clinch River Breeder Reactor Plant)	

AFFIDAVIT OF DR. KARL Z. MORGAN

City of Washington)
) ss:
District of Columbia)

I, Dr. Karl Z. Morgan, being duly sworn, depose and say that the foregoing testimony is true and correct to the best of my knowledge and belief.

Karl Z. Morgan
Dr. Karl Z. Morgan

Subscribed and sworn to
before me this 16th day
of August 1982.

Barbara Ford
Notary Public

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JUDGE MILLER: Now, do you have any others?

MS. FINAMORE: Yes, we do. Intervenors' Exhibit 2 was -- I will get it in a moment -- that was a summary of a meeting held on April 30, 1976.

JUDGE MILLER: Any objection?

MR. EDGAR: I'd like to again make sure I have the identification.

JUDGE MILLER: That's a letter to Roger Boyd from Peter Van Norten that reflects --

MR. EDGAR: No objection.

JUDGE MILLER: Okay. It will be admitted. 2 is admitted.

(The document referred to, heretofore marked for identification as Intervenors' Exhibit No. 2 was received in evidence.)

JUDGE MILLER: What's the next one? Have we ruled on 1?

MS. FINAMORE: No.

JUDGE MILLER: Reliability program. That will be admitted because it has pages which are reflective of testimony. We'll at least admit it for that purpose.

MR. EDGAR: No objection.

JUDGE MILLER: No objection. Okay. That is admitted.

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(The document referred to, previously marked for identification as Intervenors' Exhibit No. 1 was received in evidence.)

MS. FINAMORE: We do wish to have Dr. Morgan rebut a portion of the Staff's direct testimony.

JUDGE MILLER: Well, let's get through, first of all, with the pending matters and then we will permit that.

MS. FINAMORE: I believe that is all the exhibits of Intervenors.

JUDGE MILLER: All right, and that's all the --

MS. FINAMORE: Oh, excuse me. Intervenors' Exhibit 10. Our problem with that is that it's a lengthy report and we do not have copies for the Board.

JUDGE MILLER: Can you furnish the requisite number of copies of those portions which were alluded to by any of the witnesses or counsel?

MS. FINAMORE: Yes, we can.

JUDGE MILLER: Upon that representation we will admit those portions of Exhibit 10, the EPA report of September 1977, and we suggest you confer with other counsel to be sure that all pages which are alluded to are reproduced.

MR. EDGAR: The only pages discussed in the

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cross-examination were Pages 20 and 21.

JUDGE MILLER: Well, give them a chance to go through the transcript, too.

MR. EDGAR: Sure.

JUDGE MILLER: So the pages will be admitted and we request that you confer with counsel for Applicants and Staff to ensure that all of you are in agreement. If there's any doubt about a page, why, Xerox it. But I don't think you'll have any problem.

Okay. Are there any other exhibits of Intervenors which have not been ruled upon?

MR. SWANSON: Yes.

/ / /

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MR. SWANSON: Intervenors' Exhibit 3, Dr. Cochran, Part I, was never ruled on. It was never offered yesterday.

MS. FINAMORE: I believe it was offered the first thing this morning.

JUDGE MILLER: Well, I thought it was offered this morning.

Well, in any event, in case it wasn't ruled upon this morning, it will be admitted. But I'm pretty sure that you'll find that we did it the first thing.

MR. SWANSON: Okay. I also believe that there was a colloquy about the -- motions to strike, because if the Board does want to indicate -- rule today on motions to strike, we did want to raise a category of objections in that testimony.

JUDGE MILLER: Well, all right. You'll be given an opportunity.

MR. SWANSON: And the category involves every time that --

JUDGE MILLER: Well, wait a minute. We'll rule on that. That's pending.

We'll rule on that because we want to get your rebuttal testimony taken care of here.

Is there anything further that we have to rule on for Intervenors before we take the rebuttal

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testimony, at which point then we'll get back to Staff and to Applicants insofar as they have matters that haven't been ruled on?

(No response.)

JUDGE MILLER: Go ahead. Put on your rebuttal.

MR. EDGAR: Well, Judge Miller, I just wondered. Did you rule on my offer of Exhibit 33? That was the ACRS letter that was the subject of questioning.

And the Chair indicated that the letter and the questions speak for themselves --

JUDGE MILLER: Yes. Checking, I find that we did not rule upon it. We, therefore, admit Applicants' Exhibit 33, that being the ACRS letter and attachments. That's admitted.

(The document heretofore marked for identification as Applicants' Exhibit No. 33 was received in evidence.)

JUDGE MILLER: Did you have anything else that you may not have offered?

MS. FINAMORE: No other exhibits that we haven't offered.

JUDGE MILLER: Do you have any other problems before you go with your rebuttal? If the witness is here, we'd like to have the advantage of this opportunity

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bm

to discuss things with him.

MS. FINAMORE: I would like to get this one matter cleared. I believe that the order of presentation in the case all the way along has been Applicants first, Staff second, Intervenors third.

I assume that the same order of presentation would apply to rebuttal evidence, and that, therefore --

JUDGE MILLER: Don't assume too hard. Now we made that division because we were allocating the affirmative issues. We were getting them all together, and it was really to your advantage because it gave you a chance to have them all before you instead of having to bring in rebuttal witnesses seriatum. That's as far as we went.

So, again, don't reason too far from something. Post hac ergo proctor hoc nunc.

After this there will be causes. Don't rely on it. It's not only a fallacy, but you'll be in trouble about half of the time, because we have to take things ad hoc.

MS. FINAMORE: Am I correct then that you wish us to proceed --

JUDGE MILLER: You said you wanted rebuttal. We're saying, "For goodness sakes, go ahead and rebut."

MS. FINAMORE: Go ahead.

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JUDGE MILLER: Dr. Morgan's been sworn and we've got his qualifications. We're happy to see you again, Dr. Morgan, as a rebuttal witness and you may proceed.

Now, just be sure that you identify the rebuttal nature so that it isn't matters that should have been raised in chief but you can screen that out for yourself.

MS.FINAMORE: If you will permit me one moment to find the portions in Staff's testimony.

JUDGE MILLER: Surely.

Whereupon,

KARL Z. MORGAN

was recalled as a witness by Counsel for the Intervenors, and having been previously duly sworn by the Chairman, was examined and testified further as follows:

JUDGE MILLER: We have a question on the record. There may be an ambiguity with reference Intervenors' Exhibit 10.

10 is the portion which has been reproduced of the longer document, which is the EPA dose guidance.

Now, query , if we rule upon and admit Intervenors' Exhibit 10, does that completely encompass the question about the admissability of the big thick one?

MR. TOUSLEY: The copies you have were produced by Applicants.

JUDGE MILLER: You have to realize that it's a courtesy of the Appliant but the number on it is Intervenors' 10.

MS.FINAMORE: I believe we would want to check the transcript first to make sure whether these portions are the complete ones.

JUDGE MILLER: If they're not, what are you going to do? You put this in. This is your exhibit. You made a representation to us. Do you want us to strike everything about it because you don't know what's in it? This is yours.

You're just borrowing their copy -- their reproductive facilities but as far as --

MR. EDGAR: Oh, no. I'm sorry. There's a misunderstanding.

JUDGE MILLER: Well, then, I misunderstood.

MR. EDGAR: I passed that out, so they had the original of the whole volume --

JUDGE MILLER: I see it, yes.

MR. EDGAR: And I passed that out so that counsel, the Board, everybody else that didn't have the document could look at it, --

JUDGE MILLER: Well, am I in error in saying this is Intervenors' Exhibit 10?

MR. EDGAR: I think you are, Judge Miller.

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JUDGE MILLER: Straighten me out.

MS. FINAMORE: I believe Dr. Cobb has with him a portion of -- the entire document --

JUDGE MILLER: Right.

MS. FINAMORE: -- of which a portion you have in your hand.

JUDGE MILLER: Right.

MS. FINAMORE: We introduced or marked for for identification, as Intervenors' Exhibit 10, the entire document.

JUDGE MILLER: Oh, you did?

MR. EDGAR: Let me explain.

JUDGE MILLER: I see. All right. I get it.

MR. EDGAR: I passed this out so people could follow the questioning. I was going to mark it, if someone else didn't and --

JUDGE MILLER: So it is from Intervenors' 10, which is the bigger document?

MR. EDGAR: That's right.

MS. FINAMORE: A portion of it.

JUDGE MILLER: Now, you tell me you're not -- well, it's from -- yes. It obviously less than the whole.

MS. FINAMORE: Yes.

JUDGE MILLER: You tell me you can't state now whether there are any more portions of Intervenor's 10,

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the thick document, which has to be checked or something done before we could substitute for 10 this portion which has been used with the witnesses?

MS. FINAMORE: Well,I could, if given a couple of minutes.

JUDGE MILLER: How many minutes?

MS. FINAMORE: If we take a short break, I can return with the answer.

JUDGE MILLER: Five?

Can you do it in five minutes?

MS. FINAMORE: If we could take a ten-minute recess --

JUDGE MILLER: Then you can do it with super-duper, blue-ribbon special.

MS. FINAMORE: Thank you.

JUDGE MILLER: Ten minutes.

(Short recess.)

DIRECT EXAMINATION

BY MS. FINAMORE:

Q. Dr. Morgan --

BY WITNESS MORGAN:

A. Yes.

Q. You have read the site suitability report of the Staff; is that correct?

A. Yes.

Q. Does that Staff site suitability report contain an estimate of the dose to the bone surface?

A. Yes.

JUDGE MILLER: I thought I heard the witness say yes. Is that correct?

WITNESS MORGAN: That's correct.

BY MS. FINAMORE:

Q. Let me repeat the question, Dr. Morgan. I'm referring to bone surface dose, not a bone dose.

JUDGE MILLER: You mean you want to reject his answer? You asked and he said yes. What are we doing now? Are you going to overrule him?

Go ahead.

MS. FINAMORE:

Q. I'll go ahead.

Dr. Morgan, can you tell me what the Staff's bone dose estimate -- bone surface dose estimate is for the Clinch River plant?

A. I understood the estimate was 119 rem.

Q. Do you agree with that estimate?

A. No, I do not.

Q. Can you explain why you do not agree with that statement?

MR. EDGAR: Objection.

Objection. Judge Miller, I have an objection

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to the entire line of inquiry. The subject matter of rebuttal is matters raised in the affirmative testimony of another party. The inquiry here and reference to the 119 rem to the bone surface, which, if you will look on Page 10 of the -- Dr. Morgan's testimony, they're talking about analyses which have already or had been raised by the Staff before the filing of affirmative testimony.

They're relying on materials obtained in discovery in Dr. Morgan's affirmative testimony and I don't see that that falls within the nature of rebuttal.

MS. FINAMORE: Judge Miller, the reason I was confused before is that I believe the statement of the witness is incorrect.

JUDGE MILLER: We'll overrule him, then.

MS. FINAMORE: The 119 bone surface dose, to my knowledge, was raised for the first time by a witness for the Staff yesterday, based upon calculations and other analysis that had been performed. That was a matter raised for the first time.

I would simply like to have the --

JUDGE MILLER: Who raised that?

MS. FINAMORE: Mr. Bell.

JUDGE MILLER: Refresh my memory.

Mr. Bell. And who was asking the questions?

MS. FINAMORE: I was asking a question.

JUDGE MILLER: I mean you raised the issue. You raised it and now you want to rebut it?

You injected it, apparently, from what you tell me. If it was as a result of your questions, you're the one that did it, apparently.

You pleaded guilty.

If you didn't think it should be in, you think it was incorrect, why did you put it in yourself by the question which produced the answer or the computation; if that's what it was.

I don't understand you, now.

Go ahead.

MS. FINAMORE: Can I have one minute?

JUDGE MILLER: Yeah.

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17-1
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MS. FINAMORE: Well, the affirmative testimony of the Staff also does refer to dose guidelines for bone surfaces.

JUDGE MILLER: Yes.

MS. FINAMORE: It was the number that only appeared --

JUDGE MILLER: Pardon me?

MS. FINAMORE: It was the actual figure that only appeared in the --

JUDGE MILLER: Well, that's why Mr. Edgar is objecting. He's saying you had the information, you had in advance, you had it when the testimony was prepared for Dr. Morgan and, so, why didn't you go into it then instead of now having --

MS. FINAMORE: No. The actual number came out the first time. The general topic had been raised by Staff.

JUDGE MILLER: It's just the number that came out in cross, if I understand you.

MS. FINAMORE: Yes, but the issue had been raised by the Staff in its affirmative case and I can refer you --

MR. JONES: Mr.Chairman.

JUDGE MILLER: Yes.

MR. JONES: It may be that the word bone surface

is mentioned some place in the Staff's testimony but I believe the questions that elicited that number were asking whether the Staff had done other additional runs assuming transuranic -- a whole variety of characteristics and so the number she got i not necessarily related to any thing in the testimony It is related to the specific question she asked with specific assumptions on what she wanted.

JUDGE MILLER: Which was done for the first time, if I understand you correctly, by the Intervenors' Counsel in cross-examination.

MR. JONES: That's correct.

JUDGE MILLER: Well, what do you say to that?

MS. FINAMORE: One minute.

JUDGE MILLER: Okay.

You see you've got a dilemma, is what your problem is.

MS. FINAMORE: I understand.

I'd like to turn to another matter.

JUDGE MILLER: Pardon me.

MS. FINAMORE: I'd like to turn to another matter.

JUDGE MILLER: Okay.

BY MS. FINAMORE:

Q Dr. Morgan, do you have a corrected version

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of what I believe is Staff's Exhibit -- I believe it's Exhibit 3.

MR. JONES: Are you referring to the testimony in Contention 2?

MS. FINAMORE: Yes.

MR. JONES: I believe that is 3.

JUDGE MILLER: Staff 3. Okay.

BY MS. FINAMORE:

Q Do you have a corrected copy of that exhibit in front of you?

A No.

JUDGE MILLER: You're not going to strike that, are you? Everytime he says no, you --

MS. FIRNAMORE: For the record, the Staff made some corrections to this exhibit at the beginning of its testimony, in particular, changed several numbers on what I believe is Page 18.

JUDGE MILLER: You're directing his attention ot Page 18 now?

MS. FINAMORE: Yes.

JUDGE MILLER: Okay. Dr. Morgan, do you have that?

WITNESS MORGAN: Yes.

JUDGE MILLER: Okay. Your question.

17-4

BY MS. FINAMORE:

Q Dr. Morgan, do you agree with those corrected numbers of the Staff on Page 18 of Exhibit 3.

MR. EDGAR: Can we have an identification of what the corrected numbers are that are the subject of the question?

MS. FINAMORE: Yes.

JUDGE MILLER: Didn't you get the corrected numbers from Staff?

MR. EDGAR: I want to be sure I've got -- I've only got two corrections on this page. I've got the word alpha isotopes. I've got the dose factor is 2 times 10 to the minus 9 -- in both places and then I have the result, 8.5 times 10 to the minus 4.

JUDGE MILLER: That's correct. Do you have those corrections, Dr. Morgan, and no other?

WITNESS MORGAN: Yes. I haven't run them out on my calculator but I assume somebody else has.

JUDGE MILLER: Well, those are the corrections they have given you. Those are the figures they have given you as givens, resulting from corrections made by the witness when I think Dr. Linenburger got his calculator out, as I remember.

WITNESS MORGAN: Yes.

JUDGE MILLER: So, as corrected, now, ask your question.

17-5

BY MS. FINAMORE:

Q Dr. Morgan, do you agree with those calculations by the Staff?

MR. EDGAR: Objection. Is the question to the changes or the calculations?

JUDGE MILLER: Well, we'll take it either way. What do you say, Dr. Morgan?

Let's move on.

WITNESS MORGAN: No, I do not.

JUDGE MILLER: What's the nature of your disagreement and the basis for it?

WITNESS MORGAN: My basis for disagreement here is that the Staff has focused on the wrong syndrome, the wrong situation that would lead to these doses.

I feel that the sodium dose would be much larger.

JUDGE MILLER: Do you have a figure that you believe it should be or are you just disagreeing with the values you see?

WITNESS MORGAN: I'm disagreeing with the assumptions they made in arriving at this value.

JUDGE MILLER: All right.

WITNESS MORGAN: 1.7 times ten to the 3 rems per curie.

JUDGE MILLER: Fine. Okay.

WITNESS MORGAN: Which is based essentially on no deposition.

JUDGE MILLER: I see.

Anything else, sir?

I want to be sure we have your full testimony on your disagreement with the figures and the computations which are before you.

WITNESS MORGAN: Yes. Thank you, Your Honor.

It seems to me that the Staff, perhaps unintentionally, assumed no deposition because they felt that would give the most conservative answer, but that is not necessarily so.

In the early hours for this short-lived sodium 24, it has a short radioactive half life, the external dose from the gamma would be terrific. I won't take time to go through that and, furthermore, I feel that the dose calculations to the bone that are used, are misplaced.

I have, since sitting here, gone through calculations showing that the dose to the bone would be some 94 times what the Staff has indicated, using the data and using only the data in my written testimony, does one arrive at that.

Now, I have not had the occasion or opportunity to explain how I get this factor of 94. It's already in

17-7

-7

my written testimony but apparently no one has bothered to multiply these numbers out and --

JUDGE MILLER: You say it is contained in your written testimony?

WITNESS MORGAN: If one has a hand calculator and goes through it properly and I can show where they used Handbook 2, which I had part in writing a considerable portion of it, and where they used Handbook 30 at their convenience and, first of all, for plutonium 238, for example, the ORNL values that they took a look at for bone, are all -- they should be increased by a factor of 1.2.

There in those calculations, in that particular instance, they used a quality factor for alpha of only 10. They should have used 20. And the Staff values in Table 5 is against the ORNL valves for Table 6 - -

MR. EDGAR: Your Honor, I'd like to register a strong objection to this. Now, we are running in the back door.

The question started with a calculation on Page 18 of the relative radiotoxicity of sodium 24, compared with core plutonium.

Now, we are trying to wedge in the question -- a much different question having to do with relative radiotoxicity of Pu 238 and other isotopes of plutonium.

17-8

This is not rebutting the Staff's testimony on Page 18 and it does not relate to the two changes made on Page 18.

MS. FINAMORE: The entire calculations on Page 18 appeared for the first time when the Staff filed its pre-filed testimony, which was simultaneously with the testimony of Dr. Morgan. There was no way for Dr. Morgan to have rebutted those calculations in his case-in-chief, since it was filed on the same day.

JUDGE MILLER: Well, that isn't the point. The point is whether or not this is rebuttal within the scope of the direct testimony and if it is not, it would not be proper to come on rebuttal.

Now, my colleagues are of the belief that Mr. Edgar is correct in his statement but we want to be sure.

Now, maybe you want to confer with Dr. Cochran, because our threshhold belief is that you are now getting into a wholly different matter, which would be beyond the scope of rebuttal.

MS. FINAMORE: One minute.

JUDGE MILLER: Yes.

MS. FINAMORE: Judge Miller --

JUDGE MILLER: Yes.

MS. FINAMORE: It is my understanding that Dr.

Morgan is referring to one particular number on Page 18, which was corrected from 3 to 2.

Dr. Morgan's testimony right now is an attempt to explain his disagreement with that number 2. That number appeared for the first time in the Staff's testimony on Page 18.

JUDGE MILLER: Pardon me. You may want to focus on this.

I'm told that Dr. Morgan was also referring to the several lines above. You see where dose factor equals -- the line starts off, "Na24 dose factor -- ".

MS. FINAMORE: Yes.

JUDGE MILLER: Okay.

The 1.7--

MS. FINAMORE: Yes.

JUDGE MILLER: I'm told -- times 10 to the 3rd, is also involved, I'm told.

MR. EDGAR: That was a typo there, on the plutonium dose factor because if you look at the denominator, the next equation there -- someone with Dr. Morgan's qualifications would not have been misled by a change from 3 to 2.

MS. FINAMORE: My point remains that both the 3 and the 2 appeared for the first time after the -- after Dr. Morgan had filed his case-in-chief. Therefore, it's

a proper subject for rebuttal, since it could not have been discussed or rebutted before it appeared.

JUDGE LINENBURGER: The problem we're having, Ms. Finamore, is that Dr. Morgan's discussion at the point of Mr. Edgar's objection had gone into an area of quantitative evaluation, not related to Answer A 33 on Page 18, and that appears to us to be a correct observation on the part of Mr. Edgar, as we review this testimony and that gives us a problem and a problem which we don't hear you addressing right now.

JUDGE MILLER: Well, that problem becomes a legal problem now that my scientific colleagues have given me the predicate.

Rebuttal is limited. It is certainly limited to matters raised -- rebuttal is limited to matters that were raised not only for the first time, but matters raised fairly within the scope of direct examination -- I mean, cross-examination of witnesses who were put forward.

Now, this is not the time and place for you to get into matters other than that. Therefore, it gets into the legal area rather than the technical, once we get the predicate properly laid, therefore, it is beyond the scope of rebuttal.

MR. TOUSLEY: I just got confused.

Did you just say that rebuttal was within the

17-11

scope of matters brought up on cross-examination?

JUDGE MILLER: Yes. Matters that are raised by cross-examination of your own witness.

Now, you have moved into the area where you are seeking to put on rebuttal testimony to that which was presented by, in this case, the Staff's original written direct testimony. So, in order to rebut that, you must focus upon the issues and the testimony that is there.

In other words, you can't go into or raise new issues, I mean fact issues of a testimonial nature. That's what you're rebutting.

MR. TOUSLEY: Isn't that redirect?

JUDGE MILLER: Pardon me?

Well, you're rebutting affirmatively. Or seeking to. Isn't that what you're trying to do?

MR. TOUSLEY: Matters which were raised in the direct case of other parties.

JUDGE MILLER: Yeah.

MR. TOUSLEY: I don't understand why this doesn't qualify.

MR. EDGAR: It doesn't factually, that's the problem.

MS. FINAMORE: I will attempt to limit the questions and the answers to this one particular number which appears on Page 18 and not to go beyond the facts

necessary to rebut that particular number.

BY MS. FINAMORE:

Q If you can, Dr. Morgan, I would like you to explain the disagreement you state you have with the number of 2 times 10 to the 9th, rem per curie, indicated on Page 18 of Staff's Exhibit 3, and only to those reasons why you disagree with that particular number, if you would.

A. May I have a copy of the document?

Q Yes.

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18-1 he

BY WITNESS MORGAN:

A. I disagree with this factor too because it's wrong.

Q. Why is it wrong?

A. It's wrong because, as I indicated, the plutonium dose per curie, that is rems per curie, is not two times ten to the ninth, but it's a factor of 94 greater than that.

Q. And why is that, if you can explain briefly?

A. Well, it's hard to do that without a blackboard. If you like, I could put it on the blackboard.

JUDGE MILLER: I don't think we want that much detail if it can be avoided.

THE WITNESS: Okay.

JUDGE MILLER: I take it there are enough mathematicians here that can follow what you're doing.

THE WITNESS: Yes.

JUDGE MILLER: Okay.

THE WITNESS: First of all, or just to simplify the response, for the plutonium 238 the ORNL made some calculations and the Staff made some calculations. The ORNL values for lung tallied with my own, using the ICRP No. 2 publication, so I know from that that they were using a quality factor of ten and that my method of check was correct because I got identical numbers in that column. But then when I began to check for the bone I found there

18-2

was an error of 20 percent, so that's part of this number.

And then, as indicated, since I check the lung and my values checked, then I -- I was using a factor, a quality factor for alpha particle equals ten, then I knew in this calculation they had used ten rather than twenty.

And then checking the Staff's calculation, their value was twice the ORNL value. That's another factor of two. And then the Staff assumed, and ORNL assumed, that people in Oak Ridge only live for 50 years. I should have been dead 75 years ago. I'll be 75 next month.

JUDGE MILLER: You get a refund. Go ahead.

THE WITNESS: Well, I'll see what I can do about that, sir.

(Laughter.)

THE WITNESS: So I made the calculation. It's very straighforward, you get the dose rate and then you integrate from zero from T the rate, and so you would end up then with the effective half life times the rate divided by .693, a Logarithm of Base 2, times one minus e to the minus t, little t, same as the time, which I'm going to vary, divided by the effective half life for the various radio-nucleates. And so if in one case one takes your time of exposure equal to 50 years, that is, people in Oak Ridge aren't supposed to live beyond 50, you get one answer. I

18-3

did that and checked with the Staff and with the ORNL. Then I took 80 because I plan to live even more than 80, unless I get bumped off because of this testimony here, and I found there a factor of 1.5.

Now, if you multiply 1.2 times two times two times 1.5 you get a factor of 7.2. And then I used the puff release as a factor of 13, which was mentioned in my paper, and 13 times 7.2 is 94, but I've struck out the isotope factor, which was 50, because that was deleted from my testimony. The dose would be far higher were we to include that, but I'm not addressing that since that's struck from our testimony.

So the dose, then, I estimate would not be the value dose per curie, the rems per curie would not be two times ten to the ninth but would be 94 times that.

JUDGE MILLER: It would be what?

THE WITNESS: 94 times that.

BY MS. FINAMORE:

Q One point of clarification, you said earlier that the Staff's bone dose factor was a factor of two higher than ORNL's?

A The Staff's values in my Table 5, roughly a factor for bone, were a factor of two higher than the Oak Ridge calculations that I showed in Table 6.

Q One more question, Dr. Morgan; what would that

18-4

factor be if you did take into the account the isotopic concentration?

A. I'd have to multiply that one factor by 50, which was struck my testimony, so I didn't use that. That is, we're not talking about a breeder here today. It isn't the Clinch River Breeder because it won't breed unless it can use its own fuel, so we're talking about a reactor. It's not a breeder.

MS. FINAMORE: I have no further questions.

Oh, for the record, am I correct that that portion was not stricken from the testimony?

JUDGE MILLER: Which portion? I'm not sure I follow you. I don't know.

MS. FINAMORE: I believe the record will show if it was or not.

THE WITNESS: The portion referring to the isotopic distribution of plutonium 238, 239 and 240.

MS. FINAMORE: I believe the record will show. We have no need for a clarification.

JUDGE MILLER: It should, but I don't really know.

MS. FINAMORE: I have no further questions.

JUDGE MILLER: Okay. Now, let's see, that was rebuttal of the Staff, so does the Staff have any sur-rebuttal, and then Applicants will have an opportunity.

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MR. SWANSON: No, but we have a couple of questions on cross.

JUDGE MILLER: Okay. Go ahead.

MR. SWANSON: Are we following the procedure of Applicants' going first or Staff?

JUDGE MILLER: Oh, I don't care.

MR. EDGAR: I'll be glad to go first. I have just a very small number of questions.

JUDGE MILLER: Go ahead. It was just because it was the Staff's number, so I thought maybe they'd feel some pride if I -- Go right ahead.

CROSS-EXAMINATION

BY MR. EDGAR:

Q. Dr. Morgan, you mentioned that the Staff's calculation assumed that people in Oak Ridge only lived there for 50 years, am I correct?

A. No, you're incorrect.

Q. Okay. What did they assume? What did you say?

A. They assumed that when one fixes the plutonium, the various isotopes of plutonium in the skeleton and/or in the endosteal and periosteal surface tissues of the trabecular bone, that in such case this person is going to die at age 50 if he got this at a very early age. That is, they assume that the radiation of the skeleton, be it the average trabecular or particle bone or what not, or the

18-6

endosteal or periosteal tissues, they assume that the people that follow this accident, or in a normal event if there is release of plutonium, after that time they will live only 50 years, so you better -- so people should be notified then that they have only 50 years of life to live after an event. I think it should be 80 because there might be some young people here. I hope some of my grandchildren here aren't held to that restriction of 50 years.

JUDGE MILLER: We're being conservative on that, aren't we?

BY MR. EDGAR:

Q. What is the average age of people in Oak Ridge today, do you know?

A. This was my worry when I was director of the health physics program, because everybody at the lab was getting older, including myself.

Q. Do you know?

A. I know it's about as much older as Oak Ridge has been in existence.

Q. Am I correct that you do not know the average age of individuals in Oak Ridge?

A. No, I don't know, and I doubt if anyone here does, unless you happen to know.

JUDGE MILLER: Next question.

MR. EDGAR: All right.

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BY MR. EDGAR:

Q Earlier on you talked about the -- I had asked you a question about the effect of sodium, a sodium environment on the rate of aerosol depletion in containment. Do you know whether the Staff's site suitability calculation assumed any sodium in connection with assumptions made in regard to depletion of aerosols in containment?

MS. FINAMORE: Objection. I don't believe that was the scope of the rebuttal at all.

MR. EDGAR: Now she's just told me that this doesn't have anything to do with sodium with -- and let me quote from the Staff's testimony on Page 18. I'm glad to hear this because I've now been told that we're not talking about relative sodium-plutonium radiotoxicity.

JUDGE MILLER: Well, now, let's settle down. In the first place, she can't testify, neither can you. So let's see now where we are.

The objection has been made on the grounds of scope of rebuttal testimony, is that correct?

MR. EDGAR: Uh-huh.

JUDGE MILLER: Now, what happens if you get conflicting advice here? I see two of them talking to you, I don't know how you're going to come out. I want to give you a fair shot at it.

MR. EDGAR: Mr. Chairman, we're going to

18-8

withdraw the question.

JUDGE MILLER: All right. The question is withdrawn, so we don't have to rule. The objection is, let me call it moot. Dr. Morgan, they'll think of something else to ask you.

Go ahead.

MR. EDGAR: I'm sorry. I wasn't listening.

JUDGE MILLER: Are you through?

MR. EDGAR: I am through.

JUDGE MILLER: Oh, I'm sorry. I didn't hear you say that.

All right, Staff, do you wish to cross-examine the rebuttal witness?

MR. SWANSON: I think we just have one line. I'm just trying to understand the implications of Dr. Morgan's testimony.

BY MR. SWANSON:

Q Do you agree that the purpose of Answer 33 in the Staff's testimony referred to is to demonstrate relative toxicity of sodium compared with plutonium?

A I think that was one of the main objectives, yes.

Q Okay. Now, if -- do I understand your testimony correctly that what you are proposing is to substitute the number two for the plutonium dose factor to a number of --

18-9

rather than having me misstate it, would you please state it, is it 94 or 95?

A. In all these calculations and in all the values of Handbook 2 we assumed that we weren't actually justified in rounding off to more than two places, so I would not want to do that here, actually. I just gave the actual numbers when you multiplied these coefficients together.

Q. But what you would do is increase that number to --

A. Say 90 instead of 94.

Q. Okay. Now, if that number were substituted in the denominatorof the following line, in other words, the two times seven to the ninth, and you were to substitute for that somewhere around 90 times ten to the ninth, what would that do in a relative qualitative sense to the result reached in that equation? In other words, the correct number, 8.5 times ten to the minus fourth, what would that do to that number?

A. It would raise the dose accordingly to the population in case of an accident.

Q. Now, if you took the reciprocal of that higher number, compared to the reciprocal of the lower number, wouldn't the reciprocal in fact be a higher number -- excuse me, let me back up a second.

If we increase the 8.5 times ten to the minus

18-10

fourth, if we were to decrease that.

A. Where is the 8.5 times --

Q. Okay. Maybe we're getting the record confused.

A. That's not the inverse.

Q. First of all, we have a corrected number for the testimony that now stands, do you not -- I'm reading from the line relative toxicity of 8.5 times ten to the minus fourth. 8.5 was substituted for 5.7, is that correct?

A. I don't find 8.5 times --

JUDGE MILLER: Do you have that, Dr. Morgan? That was the product of one of the corrections. Now, let's be sure now that you have the corrected figures.

BY MR. SWANSON:

Q. The precise number is not important. I just want to make sure that we're talking about the same number when we're --

A. I was only referring to Page 18.

Q. That's correct. That's what I am, too.

A. But I don't see the number -- oh, yes, I see what you --

Q. The line relative --

MS. FINAMORE: Your Honor --

JUDGE MILLER: See where it says equal? Okay. We're together.

18-11

MS. FINAMORE: Your Honor, I believe that Dr. Morgan's testimony did not discuss that particular calculation. I don't believe this is within the scope of recross.

MR. SWANSON: He's substituting a number and I'm just trying to substitute it equally throughout this calculation and not just in one place.

MS. FINAMORE: Do you --

JUDGE MILLER: Yes. Go ahead.

MS. FINAMORE: I believe the Staff is asking the witness to perform the calculation.

MR. SWANSON: No, I think that would be unfair to make him do that. I'm just trying to do a relative assessment right now. It's based on simple mathematics.

BY MR. SWANSON:

Q And what I'm saying is if you were to substitute in the denominator of that line relative toxicity the number of roughly 90 times ten to the ninth instead of two times ten to the ninth, what would that do to the resultant answer?

MS. FINAMORE: I'll have to object again. I believe that Dr. Morgan has indicated a change to one number in an equation.

JUDGE MILLER: Well, then, the question so, so what difference does it make when you spread on through,

18-12

it's going to affect other results. That's what he's being asked. I think it's a proper question.

MR. SWANSON: And all I'm really trying to do is get a qualitative sense. I'm not going to press him to come up with a precise number.

MS. FINAMORE: I'd request that the witness have time to --

JUDGE MILLER: Oh, overruled. Let's go.

Go ahead, Dr. Morgan.

BY MR. SWANSON:

Q. A simple number, if you increase the denominator by a factor of 90, what is that going to do in a qualitative sense to the result?

A. Well, obviously, if you increase something in the denominator it makes your result lower, but this is -- the objection to that is you're correcting only one of the errors, and I think, having shown that the sodium is of greater pertinence and consequence -- you don't just cut off your finger to prevent pain from a bee sting.

Q. Excuse me.

A. You look at the whole problem.

MR. SWANSON: I think I would move to strike the answer as nonresponsive. I'm just trying to take the numbers -- the new number that was given on rebuttal and see what that does.

JUDGE MILLER: That's a proper question.

19-1 op

JUDGE MILLER: Do you understand the question he's asking you?

WITNESS MORGAN: He was asking me, if you increase the number in the demoninator --

JUDGE MILLER: You increase a certain number --

WITNESS MORGAN: -- doesn't it decrease the result? Well, I learned that when I was in the first grade and I think it's still true.

BY MR. SWANSON:

Q And so if you were to take the reciprocal of that lower number, again, in a qualitative sense, the reciprocal of that would be higher than the reciprocal of the number you had the first time around; isn't that true?

MS. FINAMORE: Objection. I don't understand the question. I'm not sure if the witness does.

JUDGE MILLER: I think the witness understands better than you or I do.

(Laughter.)

MS. FINAMORE: Does the witness understand the question?

JUDGE MILLER: Well, let's find out if he understands it. Let him answer it. I don't want to --

WITNESS MORGAN: I understand what he wants to ask but I don't understand what he did ask.

JUDGE MILLER: Would you like it rephrased,

9-2

Dr. Morgan?

WITNESS MORGAN: Well, I think it's the same question.

JUDGE MILLER: I think it is.

WITNESS MORGAN: If one were to increase the dose from sodium 24 per curie --

BY MR. SWANSON:

Q That was not the question.

A -- then taking the ratio --

Q That was not the question.

JUDGE MILLER: That was not the question, Dr. Morgan.

WITNESS MORGAN: What was the question?

JUDGE MILLER: Let's have it rephrased now so that Dr. Morgan can clearly understand what you're asking. Check with your experts now and then let's get it right the first time.

BY MR. SWANSON:

Q All I'm --

JUDGE MILLER: Just rephrase the question. Start off, "Dr. Morgan --".

BY MR. SWANSON:

Q Okay. Dr. Morgan, you have just indicated that if you increase the denominator of this fraction by a factor, say, 90, the result would be a number which is

decreased by a factor of 90; is that correct?

A. That is correct.

Q. Now, if you took the reciprocal of that new number, which is decreased by a factor of 90, isn't the reciprocal of that, in fact, higher than the first number that you -- result that you had?

A. Of course.

Q. So that if you --

A. Reciprocal of a smaller number, naturally, it's a larger number.

Q. Okay. I realize -- I'm just trying to get clear on the record what the result would be of increasing the plutonium dose factor from 2 to 90; so that if you were to take the reciprocal, then, -- well, I think we have that on the record.

MS. FINAMORE: I believe so.

MR. SWANSON: That's all the questions we have.

MS. FINAMORE: I have one redirect.

JUDGE MILLER: Go ahead.

REDIRECT EXAMINATION

BY MS. FINAMORE:

Q. Dr. Morgan, you indicated earlier that you believed there should be a change in the numerator of that equation; is that correct?

MR. SWANSON: Objection.

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JUDGE MILLER: No. I think she's correct, so far.

Go ahead.

MR. SWANSON: Is this redirect or re-rebuttal based on the cross --

JUDGE MILLER: Your cross-examination on rebuttal you ignored certain testimony that he had given on rebuttal with reference to that equation.

MR. SWANSON: That's correct but --

JUDGE MILLER: I think she may be supplying it. If so, she'd be entitled to. Let's find out.

Go ahead and ask your question.

WITNESS MORGAN: That is correct.

MR. EDGAR: I object to the procedure of Dr. Cochran walking back and forth between the Counsel table and the witness stand.

JUDGE MILLER: Dr. Cochran, light somewhere, please.

Okay. Go ahead.

Next question.

MS. FINAMORE: I'd like Dr. Cochran to alight over here.

JUDGE MILLER: All right. Have you asked your rebuttal -- I mean your redirect rebuttal question?

MS. FINAMORE: Just a minute.

I have one question.

JUDGE MILLER: Okay.

BY MS. FINAMORE:

Q Given your earlier testimony regarding the need to correct the numerator of that equation -- let me begin again.

In light of your original rebuttal testimony regarding the need to correct the denominator of that particular equation, would the same reasons also apply to the numerator?

MR. SWANSON: Objection.

MR. EDGAR: Objection.

She had a chance to put that on initially in rebuttal and did not and now we're trying to bootstrap little pieces of evidence in. It's just --

MS. FINAMORE: I only am going to --

JUDGE MILLER: That's your objection.

Now, what's yours?

MR. SWANSON: My objection is simply that the re-rebuttal is going beyond the scope of cross of the rebuttal.

MS. FINAMORE: I'm referring to Mr. Swanson's referral for the first time to the numerator and my question is simply tied to the scope of his cross-examination regarding the numerator.

MR. SWANSON: I don't think I mentioned the word numerator, unless it was -- it certainly wasn't a part of my question.

MS. FINAMORE: I thought your questions -- Excuse me.

MR. SWANSON: I mentioned denominator.

MS. FINAMORE: Your Honor, my understanding of Mr. Swanson's question is that, I am trying to refer my redirect to the scope of his cross on the rebuttal, which referred to both portions of the equation and my simple question relates to the portion of the equation which he brought up for the first time.

And my only question is, would the same factors apply to both portions of the equation.

MR. SWANSON: And my objection goes to the fact that I asked him to change the denominator. I didn't ask him to do anything to the numerator.

JUDGE MILLER: Weren't you looking at both? Weren't you looking at the relationship between the numerator and the denominator?

MR. SWANSON: We just asked for a simple mathematical comment as to what -- if we go any further than that, we do object.

JUDGE MILLER: I think we'll let him answer it. Do you understand the question after all this?

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WITNESS MORGAN: Yes, I do, Your Honor.

JUDGE MILLER: Your answer, please?

WITNESS MORGAN: I responded before in reference to the answer, when you change something in the denominator, you have to change your answer. And, so, I was addressing the whole equation. I could not have answered that question without addressing it.

And so the answer is, that in the syndrome that I mentioned earlier with a large amount of activated sodium 24 that the numerator would increase tremendously.

So the numerator does change.

MS. FINAMORE: I have no further questions.

JUDGE MILLER: Is there anything further or does the record sufficiently show where we are?

Nothing further?

MR. EDGAR: Nothing further.

JUDGE MILLER: Staff?

MR. SWANSON: We reserved the comment on motions to strike Dr. Cochran,Part 1, certainly. We talked about, when I raised the point before, about the Board taking up a motion to strike on Dr. Cochran,Part 1, which is Intervenors' Exhibit 3, I indicated there were some areas I wanted to -- there was one line that I wished to move to strike on and the Board indicated that we would take it up after the rebuttal.

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JUDGE MILLER: Yes, that's right.

MS.FINAMORE: Excuse me.

JUDGE MILLER: That's why we were trying to find out where we stand on rebuttal.

MR. SWANSON: Okay.

JUDGE MILLER: That's where I was but you weren't.

Are you through with cross-examination of the rebuttal witness?

MR. SWANSON: Yes.

JUDGE MILLER: Very well.

You may step down. We thank you for coming, Dr. Morgan.

WITNESS MORGAN: Thank you.

(Witness excused.)

JUDGE MILLER: Now, is there anything with relation to the rebuttal testimony of Dr. Morgan that we haven't ruled on?

MS. FINAMORE: Not to my knowledge.

JUDGE MILLER: Okay.

Intervenors' Exhibit 10. What is the status of that?

MR. TOUSLEY: We marked for us an exhibit 10, an entire document called Proposed Guidelines on Dose Limits for Persons Exposed to Transuranium Elements in

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the General Environment.

JUDGE MILLER: That's correct.

MR. TOUSLEY: For purposes of his questioning on the basis of that document, Mr. Edgar distributed portions of that to all the parties --

JUDGE MILLER: That's correct.

MR. TOUSLEY: -- and the question now is whether this portion of the document can serve as Exhibit 10.

JUDGE MILLER: Well, the question really is what you want to do about your Exhibit 10. Do you want to reproduce that big fat document?

MR. TOUSLEY: No. I --

JUDGE MILLER: Then you had better back off.

MR. TOUSLEY: -- we went through it during the last recess --

JUDGE MILLER: Okay.

MR. TOUSLEY: -- and this is sufficient for our purposes to serve as Exhibit 10.

JUDGE MILLER: Very well.

Without any further argument, the document which springs from Exhibit 10, will be known as 10A and it will stand in the records as being the only portions of the original Exhibit 10, the EPA document which has been alluded to, that need to be considered by the Board.

(The document referred to was marked

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Intervenor Exhibit No. 10A for identification and was received in evidence.)

JUDGE MILLER: Okay.

Now, anything further on the exhibits or any rulings that are necessary, with the exception of the one matter that the Staff has reserved?

MS. FINAMORE: We have --

JUDGE MILLER: All right.

There are two more things to be done.

One, you wanted to have the oppotunity to make motions with reference to Intervenors' Exhibit 3, which was the original or Phase 1 of direct testimony of Dr. Cochran; is that it?

MR. SWANSON: That's correct, but I just spoke up in response to your last question. You asked if there was anything else in the exhibits beside the point I mentioned and I did want to -- I don't want to prolong the proceeding.

I wanted to put one thing in rebuttal and I think we can do it if the --

JUDGE MILLER: I thought you told me you didn't want any surrebuttal.

MR. SWANSON: That's why I just spoke up.

JUDGE MILLER: Because you'd already told me

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wrong.

MR. SWANSON: No, no. You asked if I had any more cross.

JUDGE MILLER: Before that I had asked you about surrebuttal and you said no surrebuttal but cross on rebuttal.

All right. All right.

MR. SWANSON: It's a very simple thing. I would just like to --

JUDGE MILLER: Do you want surrebuttal now?

MR. SWANSON: I don't even need a witness, if the parties, the Intervenors, would be willing to stipulate into evidence a document that they referenced in their testimony and that is the complete Section 2.2.3 of the Staff's Standard Review Plan, which is quoted -- parts of which are quoted on Page 7 of their testimony and I would just like --

JUDGE MILLER: Page 7 --

MR. SWANSON: Of Intervenors' Exhibit 3. that's the testimony of Dr. Cochran, Part 1.

JUDGE MILLER: All right.

You're asking to put in the complete Section which is referenced there?

MR. SWANSON: That is correct. If that were done, we would not need to put a witness on.

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JUDGE MILLER: I see no reason why you can't do that. When part of a document comes -- I take it there are no objections? Is there?

MR. EDGAR: No objection.

JUDGE MILLER: Consider it done.

That takes care of surrebuttal.

Now, --

MR. SWANSON: We ask that that --

JUDGE MILLER: It will be received into evidence and marked as Staff's Exhibit -- whatever --

MR. SWANSON: Six.

JUDGE MILLER: Six.

(The document referred to was marked Staff Exhibit No. 6 for identification and was received in evidence.)

JUDGE LINENBURGER: I think there is an inadvertent inaccuracy here because Mr. Swanson, I heard you refer to that as Applicants' Standard Review Plan and I don't think that is the proper identification.

MR. SWANSON: If that's what I said, yes, I was incorrect.

I meant the document which was referenced on Page 7 of Dr. Cochran's testimony, Part 1, which is the NRC Standard Review Plan, Office of Nuclear Reactor

Regulation , Section 2.2.3 and it is a four-page document, only part of which --

JUDGE MILLER: It's been marked. It's been admitted into evidence. You will supply copies to all Counsel and the Reporter.

MR. SWANSON: We certainly will.

JUDGE MILLER: Very well.

That's it?

MR. SWANSON: That's it.

JUDGE MILLER: Now, we're down to -- well, we're not down to anything. You're through, then?

MR. SWANSON: With our surrebuttal, that's correct.

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JUDGE MILLER: Now what do you have?

MR. SWANSON: Okay. The one remaining item that we postponed was a motion to strike on Dr. Cochran's testimony, Part 1, which is Intervenors' Exhibit 3.

JUDGE MILLER: Okay. Make your motion and state the grounds.

MR. SWANSON: The motion is to strike all of those quotes, and I can go through them, of ACRS members quoted by Dr. Cochran in his testimony, the objection being that as we've had --

JUDGE MILLER: We're losing you.

MR. SWANSON: -- the Board rulings in the past, when the ACRS members are not present to be available for cross-examination, their comments may not be introduced into the record for the purpose of asserting the truth of the statements therein.

As one example, I could cite ALAB-94.

JUDGE MILLER: You don't have to cite them. I'm familiar with it. It is correct.

MR. SWANSON: And there are --

JUDGE MILLER: What do you say to that? It is a correct rule of NRC.

MR. SWANSON: And I would ask, also, in fairness, that any cross that I did on that same matter would be struck, too, but given the Board's ruling on postpoining

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motions to strike, I felt I had to cross at the time.

JUDGE MILLER: What do you have to say to that?

MS. FINAMORE: Mr. Swanson, I'd like to know what particular portions of the testimony you're referring to.

MR. SWANSON: Fine. Again I'm referring to Intervenors' Exhibit 3, that's that testimony of Dr. Cochran, Part 1, and I'm restricting myself to quotes of the ACRS members.

JUDGE MILLER: Well, can you refer -- now, your motion is to strike all references to the statements to or from the ACRS members under the NRC rule that they can't be cited or quoted to prove the accuracy or inaccuracy -- it's not evidence because you cannot have cross-examination. That's a rule we recognize and therefore we will strike the references to it but we will also strike anything you put in --

MR. SWANSON: Yes.

JUDGE MILLER: -- or anybody else put in on cross, so the whole matter will be deleted.

MR. SWANSON: I would -- as part of my motion I would move to withdraw any questions or answers by myself in cross yesterday.

JUDGE MILLER: Well, that motion has to be allowed.

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MS. FINAMORE: I'd like a clarification, if I may. I asked Mr. Swanson to refer me to the testimony. He has not yet done so, but if I may go to an example, on Page 28 of Exhibit 3 we have cited a quotation -- or let me get another example.

JUDGE MILLER: Well, that's perfectly cognizable, isn't it? It's exclusion of CDA's to the ACRS Now, you've got statements in there on that page. Those will have to be stricken, so note Page 28, the quotations. And you might be getting them together in one place so the record will be complete on what we're striking.

MR. SWANSON: Okay. Page 28 just referred to.

JUDGE MILLER: All right. That's two now. Down at the bottom is again a check, I think, isn't it?

MS. FINAMORE: That's my question, Judge Miller.

MR. SWANSON: Okay. I --

JUDGE MILLER: The advice stated to ACRS people. It's the same rule. It's taken from the minutes of the meeting, so that will be stricken, which is the latter paragraph -- latter quoted paragraph on Page 28, extending for almost two lines of quoted material at the top of Page 29, and then we're going to have more, I think; yes, Mr. Carbon, Mr. Check, the balance of the quoted material to or from ACRS on Page 29 will likewise be stricken.

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MS. FINAMORE: My clarification is --

JUDGE MILLER: Yes.

MS. FINAMORE: -- this, or my request for a clarification, does that same rule apply if the person quoted is appearing as a witness at the particular hearing and can be cross-examined?

JUDGE MILLER: It would depend.

MS. FINAMORE: On what?

JUDGE MILLER: Well, it depends on who the witness was, what the questions or what the answers were. In other words, I can't rule in a vacuum.

MS. FINAMORE: Well, that's why I'm asking Mr. Swanson to identify the portions, because I believe we quote statements of witnesses that have appeared here this week to the ACRS.

JUDGE MILLER: Well, they may or may not, but they were not asked. What we -- all that we have in the record here now are the quotations of statements to or from ACRS, and people addressing them, Staff or otherwise. That's all that's in the record. You put nothing in, no one else did. All we do, under our rules, we have to strike that because we cannot let it stand for any purpose, whether it helps you or helps the Staff or anybody else. It's not a rule that is discriminating, but we are therefore granting the motion to strike all quotations from ACRS

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meetings and statements to or from ACRS across the board, and in fairness if there be anything in cross-examination that the Staff got in through that guise, it will be stricken, too, which is in fairness to you.

MS. FINAMORE: My example is on Page 38, where we cite statements of Mr. Clare, who was here as a witness this week.

JUDGE MILLER: Yeah, Mr. Clare is and was here, that's true, but what you're quoting there are ACRS transcripts, which will be stricken.

MS. FINAMORE: But he was available for cross-examination and --

JUDGE MILLER: Well, now, that's another matter.

MS. FINAMORE: -- rebuttal and redirect, and his statements --

JUDGE MILLER: It's another matter.

MS. FINAMORE: -- although hearsay, are reliable, since he is here to respond to any --

JUDGE MILLER: It isn't a question of hearsay. It's a question of our own Appeal Board rulings. To get at it, fundamentally, it's the nature of the matter; just as the Commission has rules on the things they say can't be used in trials, too. It's not a hearsay matter. It's a fundamental policy matter. So it's granted and it works

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across the board. It's a neutral rule. It will be stricken. If you can identify it for the record now, I'd just as soon get this thing closed out and get our scheduling and be able to conclude this phase of things. I would hope you'd be able to, but if you can't, that is something that could be supplied. You can all tell what is or is not a quotation or matters that are in the transcripts of ACRS proceedings. Those will be stricken uniformly. Any references to them, insofar as they appear in the transcript from oral testimony or cross-examination, will likewise be stricken.

Okay. Can you identify now or do you want to do it later? I don't care.

MR. SWANSON: I think it would be a cleaner record if I were to do it writing.

JUDGE MILLER: Let's do it cleanly, then, and I'll give notice to opposing counsel, or other counsel, so that they may, and you may, agree that whatever your final version is is a joint statement for the record.

MR. SWANSON: Okay. Now, the same objection, I should say right now, would go to Dr. Cochran's Part 2 testimony.

JUDGE MILLER: It would go to all testimony, whoever gave it. And in the future, avoid it, because the rule is quite correct. In the future, by the way, don't forget question and answer, Q/A form of written testimony.

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MR. SWANSON: Finally, I just have one other part to the objection, and that refers to a quote on Pages 6 and 7 of Dr. Cochran, Part 1. It's a quote from the Staff's FES, which, of course, is beyond the scope of this proceeding.

JUDGE MILLER: What's that? What's that objection?

MR. SWANSON: The bottom of Page 6 --

JUDGE MILLER: Yes.

MR. SWANSON: -- about two-thirds of the way down --

JUDGE MILLER: Yes.

MR. SWANSON: -- a quote begins from the Staff's FES --

JUDGE MILLER: Yes.

MR. SWANSON: -- and continues on to Page 7.

JUDGE MILLER: What's wrong with that?

MR. SWANSON: Again, if it's being asserted for the truth of the matter therein, the FES is not in evidence and I --

JUDGE MILLER: Would you rather have it as a --

MR. SWANSON: -- it's outside the scope of this proceeding.

JUDGE MILLER: Would you rather have it as an admission against interest?

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MR. SWANSON: Well, that's the problem when we get into quotes.

JUDGE MILLER: I think you better leave it, because the one reason that we're having to have a bifurcated hearing is because of the recirculation. We're not going to put anybody to any disadvantage. That may stand. The objection is overruled.

And by the way, you're still going to get the product of your recirculation by November 1, are you not, or before, if you can.

MR. SWANSON: Well, as I indicated, that was the Staff's goal, and I think the Staff has every intention that we'd make it, but I did indicate the qualification and that is the assumption that they would not be otherwise diverted in responding to massive discovery questions.

JUDGE MILLER: Wait a minute. What was that, now, that last part?

MR. SWANSON: It's the qualification I stated to you at the time, when the Board indicated that discovery was opening up on all old environmental matters --

JUDGE MILLER: Yes.

MR. SWANSON: -- that being that the Staff's November 1 deadline, which I believe is a firm deadline, was predicated on the Staff making a dedicated effort in preparing that, and it was not based on any assumption of

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having to spend time in responding to extensive discovery.

JUDGE MILLER: Now, you can get somebody else to spend that time on discovery. These documents have been here for five years or more; we don't buy that. Hire more people, if you have to. Now, we don't want any delays caused by anybody. You're just going to have to --

MR. SWANSON: I'm sure the Staff will make every effort possible, but when you have the same people working on both --

JUDGE MILLER: Well, I'm sure, making that kind of an effort, that you're going to succeed.

All right. We move now to the scheduling matters. The proposed findings, which we've indicated to you are not formal and are going to require a lot less time because three-fourths of it you've already done in preparing your own direct testimony and your cross-examination, will be due simultaneously on October 4, 1982.

Now -- pardon me?

MS. FINAMORE: I have two responses to that. First of all, Intervenors have not prepared most of their proposed findings to their direct testimony. In fact, a very large portion of it will be through their cross-examination, and we require sufficient time --

JUDGE MILLER: Well, all right, you read the transcript. We think two weeks is enough. We're being

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generous by giving you until October 4, because that's not the most of the effort that you're going to be expending the next several months. That's the minor part.

MS. FINAMORE: My second point is that you originally stated that 45 days is a reasonable one. We see no reason that we should not be given 45 days.

JUDGE MILLER: Well, we see a reason. We pointed out to you that you people in some cases have taken a lot of time on unnecessary matters so now we're directing you to the necessary matters. We think two weeks should be sufficient. We're giving you almost five weeks.

MS. FINAMORE: The reason --

JUDGE MILLER: Once again, you're going to have to conform to our schedule; we told you it isn't a negotiable schedule. We told you that.

MS. FINAMORE: For the record, I'd just like to state that since no decision is hinging upon those proposed findings and in fact since the hearings are bifurcated and they will continue, we see no reason not to give us the 45 days, since it will not speed up the hearing.

JUDGE MILLER: There is no right to 45 days. It's wholly discretionary with the Board. The 45 days includes the formal findings of fact, conclusions of law and briefs. We're not asking for those. We're asking for a seriously truncated findings of fact on partial issues.

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We're quite familiar with what those are. We're quite familiar with the fact that NRDC and the Intervenors are engaged in activity involving this Board on the Appeal Board and at the Commission level and I think you may have some lawsuits, I don't know, it's your own business, but don't tell me how busy you are.

MR. EDGAR: Mr. Chairman.

JUDGE MILLER: Yes.

MR. EDGAR: The Appeal Board issued ALAB-688. They turned down the petition for directed certification.

JUDGE MILLER: When was that?

MR. EDGAR: Well, I got it by telecopy yesterday.

JUDGE MILLER: How come nobody tells me these things? Well, anyhow --

MR. EDGAR: I'm sorry I didn't. I --

JUDGE MILLER: It's all right. It's all right.

Well, you've got what, now? I was going to say you've got one less, but I don't know where you're going with that one. Okay.

All I'm saying is I appreciate the fact that it's a short schedule under the circumstances, although it's involving matters that have been pending for years, but we told you in the beginning it was no rose garden. We told you that, I think, in December or January of this

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year. This is a very important case. It's going to get first attention. It's the most important case in your office, in my office --

MS. FINAMORE: That's why we feel we need additional time, when it will cause no prejudice to the additional hearing.

JUDGE MILLER: What you need is additional help, probably. What you need are additional help on the one hand and less diversion of your activities and time on the other, but that's your judgment. I'm not going to tell you how to handle it, but I am going to tell you what is necessary for this proceeding with this Board, and you decide how you're going to do it.

Now, this was the easiest one, October 4 for the shortened findings of fact only, simultaneously, no response is required, and we're not expecting you to into great detail. We want your transcript references, however, and your exhibits.

However, we want you to start discovery immediately, which is the coming Monday, which date I don't know, on the discovery on environmental or NEPA matters on everything except the final supplement to the FES, and that will consist of, at the very least, the long, extensive and five- or six-year-old FES, the draft supplement, any other documents, materials or information

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which has come to your attention through interrogatories, answers thereto, or otherwise, we expect you to start on that immediately. We're going to terminate that discovery October 18th for the reason that we're going to require your prefiled testimony on all environmental and NEP matters, with the exceptions that I stated, by November 1, and we're going to go to trial November 15.

Now, that might be the afternoon. I'll have to refine that in terms of the logistics. It might be in the afternoon, but at any rate, November 15 is when we intend to resume, and that resumption is going to include NEPA and environmental matters, a substantial portion of which are already described for you in terms of the NEPA termination of discovery and the prefiled testimony and it will also include those matters triggered by and as a result of the Staff's final supplement to the FES, which is to be filed on or before November 1, according to present indications.

That means you're going to have a short period of discovery on that, as I pointed out to you when we were interpreting the statutes one time, or these regulations, but they clearly contemplate that it's to be done immediately and in no event not more than 30 days, I think it is, and in this case it's going to be for a hearing which starts November 15.

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JUDGE MILLER: Which means that you had better start with your pre-filed testimony pretty shortly, because the bulk of it is going to be available from existing documentation and not wait frantically until the final supplement is filed.

MS. FINAMORE: Judge Miller, you haven't included any provision for filing testimony related to the final impact statement.

JUDGE MILLER: Yes, I have, becauese we want it -- November the 15th is a Monday We will want that by the previous Friday.

MS. FINAMORE: What's the date on that?

JUDGE MILLER: I don't know but we'll find it. apparently it's the 12th, if I'm looking at the right calendar. The 12th.

Now, you're going to have to exchange these things immediately, hand deliver and so forth and the Board, also.

MS. FINAMORE: Judge Miller, I need an explanation of what you mean by a short period of discovery.

JUDGE MILLER: Short period of discovery? Well, I would say -- which discovery are you talking about?

MS. FINAMORE: Well, we don't have ny -- you gave a final deadline for discovery of October 18th.

JUDGE MILLER: That is the FES, multi-volume, a lot of it. That is the draft supplement, has information

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that has been furnished both through the years and more recently for the last year, in the various filings that the parties have made on Environmental, NEPA matters,your own brief to the Commission, all the rest of it. The whole body of information --

MS. FINAMORE: My only question on that refers to the deadlines for response once interrogatories or other discovery has been filed?

JUDGE MILLER: Well, since we're terminating discovery, it means you should file whatever it is that triggers it. Usually it's interrogatories,filed within a sufficient period of time so that you can get the answers.

MS. FINAMORE: Yes.

JUDGE MILLER: What is the period? Fourteen days for interrogatories?

MR. EDGAR: Fourteen, yes,sir.

JUDGE MILLER: That means fourteen days before that date you should file, so they will be in your hands or if it's depositions, you can schedule your notices and that kind of thing. There are various kinds of motions available for discovery. Time them so that you get back, if you're the requesting party, by the date for the end of discovery, October 18th.

MS. FINAMORE: My problem is that the two-week normal response time does not fit --

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JUDGE MILLER: Well, do you want it shorter?

MS. FINAMORE: No. It does not fit into the period after November 1st.

If the parties have two weeks in which to respond, after November 1st, we would go beyond the 12th deadline.

That's my question.

JUDGE MILLER: Look. I'm telling you. First of all, the October 18th date goes to this body.

MS. FINAMORE: I understand that.

JUDGE MILLER: Okay.

That's that one.

MS. FINAMORE: Yes.

JUDGE MILLER: Okay.

Now, assuming that the Staff keeps it schedule, its recirculation schedule, you've got in hand now -- you've got the draft which when you go with the discovery on that, you will have a very significant portion of what you're ever going to get from a final supplement.

Nonetheless, that's available to you now.

MS. FINAMORE: We don't agree with that, but --

JUDGE MILLER: Then the final supplement, November 1, there we will ask that the rules of the time to respond be foreshortened. We expect there you are going to have, what, five days or so. It's going to have to be

done very quickly, by all of you, because you're going to receive it on the first, you're going to have complete discovery by the 12th, which means that if you can't sit down and negotiate it out, we'd have to rule, but we think you should because you'll all be in the same boat.

In other words, for a limited final supplement, you're all going to have to proceed very expeditiously and less time,which we have the discretion to shorten the time for responses, mutually.

MS. FINAMORE: Are you proposing five days for a response?

JUDGE MILLER: No. Two days. Four days.

MS. FINAMORE: I don't know if the parties will be able to reach an agreemen on that.

JUDGE MILLER: You ought to try to agree. If you get it the first and you're going to have to get your pre-filed testimony in the 12th, Friday, obviously you're going to want to have, so far as you can at any rate, the information from discovery.

MS. FINAMORE: I would hope so.

JUDGE MILLER: Well, that means you move speedily.

MS. FINAMORE: Well, could you give us some dates on that, Your Honor, I'm trying -- It's going to be difficult to figure out how we can complete discovery --

I mean, get the final impact statement November 1st, read the impact statement, prepare the discovery questions, receive the discovery questions, read the discovery questions and file pre-filed testimony on those discovery questions in twelve days.

MR. EDGAR: I am really wondering why we are arguing about this. As I understand it, if you work backwards, we start hearings November 15th.

JUDGE MILLER: Correct.

MR. EDGAR: The parties are supposed to file their pre-filed testimony on November 1. Everybody knows what these contentions are and, at least I think we've known now for seven or eight years --

MS. FINAMORE: That's untrue.

MR. EDGAR: -- we think we --

JUDGE MILLER: Whatever.

MR. EDGAR: -- know what the issues are and we can file that testimony. What the Board then contemplates is the FES Supplement comes out and what you're really talking about there is supplemental testimony addressed to new matters first raised in the FES final supplement --

JUDGE MILLER: Correct.

MR. EDGAR: -- within the scope of the contentions --

JUDGE MILLER: And not within the scope of the

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draft supplement.

MR. EDGAR: That's right.

JUDGE MILLER: Which is where the bulk of --

MR. EDGAR: It's still going to be encompassed within the scope of the contentions. So, --

JUDGE MILLER: That's right.

MS. FINAMORE: We have no way of knowing at this time how much material is going to be in there.

MR. EDGAR: I'd like a chance to finish.

JUDGE MILLER: Wait a minute.

THE REPORTER: I can only get one at a time. I need a recess, if we're going to keep up like this..

JUDGE MILLER: We will continue this off the record for the time being.

(Discussion off the record.)

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JUDGE MILLER: Okay. We're going to put this on the record in case that it isn't. We may already have it on the record, but the proposed findings, which are of a limited nature and covering only the proceedings so far, neither formal nor going into conclusions of law, and the like, as we have explained, shall be filed simultaneously on October 4, 1982.

But as far as the balance of discovery on all matters, environmental, NEPA, and the like, with the exception solely of those matters encompassed by or triggered by the final supplemental -- final supplement to the FES, the discovery shall start August 30, and proceed expeditiously, but such discovery shall be concluded by October the 18th, 1982, and that requests for discovery, of whatever kind or character, shall be timed in accordance with the existing rules of practice, to be filed by such date as to produce the responses thereto by the end of discovery on October 18. Interrogatories, 14 days, for example, you've got to get them more than 14 days before the time the responses are due, and similarly.

Prefiled testimony, again on this body of information, NEPA and environmental and the like, will be due November 1, 1982.

We anticipate that the Staff will file its final supplement to the FES, as presently indicated, by,

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on or before November 1. Now, with that expectation, we therefore have foreshortened all the rules of discovery so that the matters that are triggered by that, not matters that should have been anticipated from the draft or from the draft supplement or other information, but triggered by that final supplement, the prefiled testimony will be due November 12.

This requires the utmost cooperation of all of you in the precedent discovery which will enable you to file the additional prefiled testimony, which is going to be pretty limited -- well, it will be limited to those matters triggered only by information contained in the final supplement. That will be filed November 12, because we are then going to start the evidentiary hearing on the remaining matters, since we've now concluded this portion of the bifurcated phase, will be the NEPA and environmental matters, on November 15. There is a possibility that we will start in the afteroon of the 15th. We'll have to -- we have to check out some various matters, but we do anticipate it will be the 15th, for that week, and that we will reserve also the week of December the 13th, 1982, to conclude those matters which are cognizable under an LWA-1 and which must then at that point necessarily await the SER and SSER for the balance of LWA-2 or LWA.

Is that correct, Staff?

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MR. SWANSON: Yes, it is.

JUDGE MILLER: Do you have -- just for scheduling now, we're not holding you to it at the moment, when do you anticipate that the SER or the other matters which would enable us to go into the final stages of the LWA -- I think we've been told it would be early spring, or something, when do you expect it?

MR. SWANSON: We do not have a date right now, and I think that probably the best way to handle this is to try to get a letter out to the Board and parties --

JUDGE MILLER: All right.

MR. SWANSON: -- shortly, is our best estimate.

JUDGE MILLER: So for future planning, I think that would be helpful, so as soon as you reasonably can would you, technical staff people, and so forth, let the parties and the Board have some indication of the SER and SSER probabilities. We don't need that for present scheduling.

MR. SWANSON: We will. Fine.

JUDGE MILLER: Okay. Now, it's my understanding the Applicants are not asking for a partial initial decision on these bifurcated matters, or the matters we took up this week, the matters that we'll be taking up on NEPA and environmental in November and December, there will not be any requirement for a partial initial decision.

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MR. EDGAR: No, sir.

JUDGE MILLER: There will be one initial decision, then, which will await the SSER and the rest of it in the spring or whenever it is when everything is encompassed, at which point, now, your proposed findings will be, what you've been worrying about, that will be the more formal type but we'll get into that later.

MR. TOUSLEY: All right. There will be one ruling on LWA-1 and LWA-2, is that what you mean?

JUDGE MILLER: It will be one, just one.

Had the Commissioners not acted, we probably would have been asked to give a partial initial decision in December, I suppose.

MR. EDGAR: Yes.

JUDGE MILLER: Now that there's no longer a necessity because the equivalent of an LWA-1 in early site work has been granted directly by the Commission, we are doing it in an adjudicatory frame because it's necessary to get an LWA-2 or to have a total LWA adjudicatory order. Right?

MR. TOUSLEY: Right, which postpones the final decision which triggers the appeal process.

JUDGE MILLER: I don't know whether it does or not. I can't count your appeals in given numbers. I can't keep track of them and I'm not -- I have nothing

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to do with that. You're entitled to it. Do whatever you wish. Whether or not something has a bearing on it, I can't say. I don't really know. I don't want to figure it out, and it's really none of my business. You're free to do what you like.

Now, we're about the reach the point at which we adjourn this bifurcated phase. It's about 3:08 -- well, 3:07:35, 36, count, anything further, once, twice, that's it. Thank you very much, and we'll see you shortly.

(Whereupon, at 3:10 p.m., the hearing in the above-entitled matter was recessed, to reconvene November 15, 1982, time and place to be noticed.)

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NUCLEAR REGULATORY COMMISSION

This is to certify that the attached proceedings before the

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in the matter of: CLINCH RIVER BREEDER REACTOR PLANT

Date of Proceeding: 27 August 1982

Docket Number: 50-537

Place of Proceeding: Oak Ridge, Tennessee

were held as herein appears, and that this is the original transcript thereof for the file of the Commission.

Mary L. Bagby

Official Reporter (Typed)

Mary L. Bagby

Official Reporter (Signature)