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, 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).

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% 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

	Staff DCFs (rems/curie)	
Isotope	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 Frost
Notary Public

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. FRANK VON HIPPEL

City of Washington)
) ss:
District of Columbia)

I, Dr. Frank von Hippel, being duly sworn, depose and say that the foregoing testimony is true and correct to the best of my knowledge and belief.

Dr. Frank von Hippel

Subscribed and sworn to
before me this 11th day
of August 1982.

Harry N. Lindstaff
Notary Public

My Commission Expires February 28, 1985