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24 December 1990

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judge
Peter B. Bloch

In the Matter of THE CURATORS OF THE UNIVERSITY OF MISSOURI (Byproduct License No. 24-00513-32; Special Nuclear Materials License No. SNM-247)	Docket Nos. 70-00270 30-02278-MLA ASLBP No. 90-613-02-MLA RE: TRUMP-S Project

DECLARATION

OF

TRUMP-S REVIEW PANEL

VDS03

Intervenors' Exhibit 20

REBUTTAL DECLARATION OF TRUMP-S REVIEW PANEL

We, members of the TRUMP-S Review Panel, declare as follow:

1. This technical review panel was established at the request of a number of groups and citizens in Missouri who desired an independent assessment be performed of the University of Missouri's application to conduct the "TRUMP-S" project at its Columbia campus.

2. "TRUMP-S" stands for TRansUranic Management by Pyroprocessing-Separation. It is a joint project of Rockwell International and two Japanese interests, Kawasaki Heavy Industries and the Central Research Institute of the Electric Power Institute. TRUMP-S is designed to find inexpensive ways of extracting plutonium and other transuranic elements from high level wastes in order to recycle them in reactors and to dispose of the remaining 90+% of the high level waste in low-level surface dumpsites rather than more expensive deep geologic repositories. It is our professional opinion that both purposes would be extraordinarily injurious to the public interest, and that the project poses unacceptable safety risks to the people living and working nearby.

3. This review panel consists of:

a. James C. Warf, Professor Emeritus of Chemistry at the University of Southern California and Chairman of the Southern California Federation of Scientists. He is the former Group Leader of the Analytical and Inorganic Chemistry Sections of the Manhattan Project and holds a number of patents for key studies which led to the PUREX plutonium reprocessing process. He has specialized for over forty years in the chemistry of nuclear materials. He made the primary contribution in our review to issues of release fractions, isotopic composition, and actinide chemistry matters.

b. Daniel Hirsch, former Director of the Adlai E. Stevenson Program on Nuclear Policy, a research and teaching program on nuclear matters at the University of California, Santa Cruz. He is currently President of the Committee to Bridge the Gap, a Los Angeles-based organization specializing in nuclear issues. Along with Professor Warf, he co-chaired and coordinated the review panel's work.

c. Sheldon C. Plotkin, a consulting safety engineer specializing in accident analysis. Dr. Plotkin's primary contributions to the review were in matters related to appropriate safety engineering standards and accident analysis matters.

d. Miguel Pulido, a consulting mechanical engineer specializing in energy, ventilation, and airflow matters. He contributed primarily to consideration of the HEPA, ventilation, and airpathway assessments.

e. Lowell Wayne, an environmental scientist and chemist specializing in the behavior of airborne pollutants. Dr. Wayne performed the initial dispersion calculations.

f. Joseph K. Lyou, Associate Director of the Committee to Bridge the Gap. Dr. Lyou performed the variation analysis, scaling Dr. Wayne's initial dispersion calculations to a range of assumptions about release fractions and initial quantities of transuranics involved in the accidents being analyzed.

g. Myron Wollin, a radiation and health physicist with 25 years experience in the field, who performed the review of explanation by the University and the NRC staff of the former's inaccurate description in the amendment application of the curie limit and isotopic composition of the requested plutonium sample.

Statements of professional background for the first five members of the panel are appended to our declaration of 15 October and for the last two at the end of this declaration.

4. Our original review touched upon the following general matters:

a. The adequacy of the University of Missouri TRUMP-S license applications.

b. The adequacy of the NRC staff review of the applications.

c. The adequacy of the 2-page "accident analysis" prepared by the University after the license amendments were granted by the NRC staff.

d. The adequacy of certain other materials available for review as of the date of our October declaration.

e. The potential safety, environmental, and related impacts of the TRUMP-S project.

5. Particular issues addressed included:

a. Problems involved with the university's release fraction estimates for accident analysis purposes, as well as their dispersion assumptions. Here we have reviewed in detail the available literature on release fractions for transuranics. We concluded that releases orders of magnitude larger than those assumed by the university are possible, involving potential doses to members of the public in unrestricted areas very much larger than the university is prepared for.

b. The adequacy of planned response measures in case there were an accident in order to mitigate adverse impacts. We concluded that such measures are either non-existent or grossly inadequate.

c. The adequacy of site characteristics to mitigate effects on the public were there an accident. We found these characteristics seriously inadequate due primarily to the urban siting and complete lack of exclusion or buffer zones.

d. The adequacy of measures to prevent such an accident from happening. We concluded that the procedures, experience, equipment, and, most importantly, attitude create an unacceptable likelihood of accident. We

were particularly troubled by the attitude that dogmatically presumes that a worst-case release cannot possibly hurt anyone and that therefore there is no need to have procedures to prevent it from occurring. This is a recipe for serious trouble.

The bases for these and other conclusions were detailed in our October declaration.

6. We noted at the time, and reiterate now, that our independent review has been significantly hampered by the sparse nature of the information publicly available. The primary document upon which the Applicant is to meet its burden of proof that the application should be granted is the application itself, which in this case consisted of approximately a mere 22 pages, to which a few attachments were included, primarily some vitae. No documents whatsoever exist supporting the NRC staff's decision to grant the license; no safety evaluation report or environmental assessment or impact statement was prepared by the NRC staff, or any other evidence of independent review. The only staff documents which exist are the form letter transmitting the approved license amendment and an affidavit, now belatedly admitted by the affiant to be incorrect asserting that the quantity of byproduct material requested by the university was less than the amount specified in 10 CFR 30.32(i)(1).

7. We noted further that the documentation we feel is essential for an independent review to be possible has yet to be provided. In particular, our review of the adequacy of administrative and managerial controls of the Applicant has been severely hampered by the refusal to include most inspection reports, notices of violation, and annual reports in the hearing file. Our review of the adequacy of the site characteristics and building features has been severely hampered by the refusal to provide the information included in past renewal applications and assessments.

8. We stated in our original declaration:

> We find it extremely frustrating to attempt a review of the proposed TRUMP-S project at MURR when so little relevant documentation either exists or is publicly available for such a review. We are forced to guess, for example, based on fragmentary statements made by University representatives at public meetings and bits and pieces of documents not contained in the application, what assumptions the University would have included in a safety analysis or emergency plan had it included one in the application. This is no way to have to conduct an independent technical review of safety issues associated with a public licensing matter, particularly one of importance to public health and safety and common defense and security.
>
> The full information needed for review should be detailed at the outset in the application, made publicly available for independent scrutiny, and then a determination made whether it stands up to such scrutiny. Independent reviewers must have the material in hand which is to be reviewed--a principle so fundamental it should need not have to be stated. In this case, however, the incomplete "hearing file" and the essentially identical applications are so

devoid of the necessary information, analysis, and plans that "there is no there there," to use the words of Gertrude Stein. We have conducted this preliminary review, therefore, based on the clearly incomplete hearing file and what snatches of additional information we have been able to obtain to date, but we must note our disapproval of how very incomplete is the information that has been made available to date.

It is our professional opinion that the meager information put forward in the applications cannot sustain the University's burden, as we understand it, to provide sufficient assurance of the safety of the applied-for activities. It is further our professional opinion that the "hearing file" as initially compiled by the NRC staff and since supplemented, is wholly insufficient to permit a licensing board to properly make the findings required of it under the Atomic Energy Act and the NRC regulations (i.e., an affirmative finding that the proposed activities will not result in unreasonable risk to public health and safety or be inimical to the common defense and security.)

9. We find it therefore somewhat amusing for the Applicant to accuse us of relying on "library research" in our discussion of the typical isotopic composition and total curie content of weapons-grade and reactor-grade plutonium in our effort to--correctly, we might add--point out that the application's claims about isotopic composition and total curie content of the material they themselves had requested were in error, when the actual isotopic mix and total curie content were not included in the application, as required, and only the applicant had the actual information, which should have been included in the application from the start.

10. We find it similarly amusing that we are accused of not knowing the precise dimensions of open passages in the MURR basement which smoke could fill in case of fire, when that information is likewise not included in the application and the Applicant, Staff, and presiding officer have all opposed including in the hearing file any information relevant to site characteristics at MURR, such as should have been included in the applications at issue (in an SAR or ER, for example) and would be found in facility annual reports and initial and renewal license applications. (Nonetheless, our calculations were based on an assumption of 1500 m^3, based on dispersion estimates we had performed for another university nuclear facility, and Dr. Langhorst's affidavit uses the figure of "greater than 1400 m^3," not a bad fit when we had been denied access to the necessary information.) Licensee's Exhibit 2, p. 18.

11. We also find it somewhat surprising that the Applicant, rather than respond to our review group's October declaration and the lengthy attached analysis by Professor Warf of several dozen studies on plutonium release fractions, instead attempts to focus on our June declaration. Furthermore, we find it strange that the Applicant would repeatedly attempt to characterize our discussion of release fractions as an attempt to misapply Chernobyl, when there is no such discussion whatsoever in our October declaration and the sole reference to Chernobyl in our June declaration was to show that the Applicant's assertion of something magical about plutonium release such that it could never be greater than 10^{-6} was demonstrably wrong. We urged then--and Applicant did not do, but we did--a complete

review of the scientific literature on release fraction experiments. These experiments show release fractions up to 50% and higher; continued use by Applicant of 10^{-6} is clearly non-conservative. The 3% figure we used as an example, based largely on a careful reading of the two sources mis-cited by Applicant for its original 10^{-6}, is certainly not the bounding release fraction; considerably higher ones are suggested from the experimental literature that we described in our review panel declaration and attached critique.

12. We are also struck by the effort Applicant has put into the issue of whether ten grams of the plutonium it has requested would represent 1.9+ curies or 2+ curies, which obscures the fact that the Applicant's application was for a maximum of .71 curies. This focus on whether the plutonium is a few millicuries above or below 2 curies neatly diverts attention from the fact that we had pointed out in our original panel declaration--that the curie content of the 10 grams requested certainly was considerably more than the maximum 710 millicuries applied for and authorized, and that it contained in significant quantities isotopes not identified in the application. Applicant now admits the presence of approximately 1200 millicuries of plutonium-241 and 70 curies of americium-241, in addition to the 710 curies it had previously declared, bringing the 10 gram total to nearly triple the curies applied for, but it attempts to divert attention from that error by focusing instead on whether this is a tad below or above 2 curies. The presiding officer has ruled within the last few days that he will not permit us to put forward evidence on that matter. We have spent a considerable amount of time over the last several weeks performing detailed calculations regarding the applicability of the additional emergency planning requirements, but at the last moment he has precluded us from presenting them. (We note, however, that he has reversed previous findings of his that the quantity was less than 2 and now finds it is over 2; see Memorandum and Order of December 19 at p. 16). Had we been permitted to do so, we would have presented here detailed calculations on that matter.

13. Applicant was able to divert attention from its error in the total curie content (its claim of .71 Ci instead of ~2) by taking advantage of an error the presiding officer made in his Memorandum and Order of 20 October 1990, which referred to "a serious question" as to "whether the Licensee is in compliance with the amended license that has been issued to it--which permits it to possess a total of two curies of plutonium." (p. 3). The presiding officer erred in this statement, as the amended license limit was--and is- 710 millicuries (SNM amendment application, February 20, p. 1). But this error on the part of the presiding officer, which Applicant knew to be error, provided a vehicle for focusing on the 2 curie number rather than the .71 curie limit it had applied for.

14. The 2 curie figure was relevant, we believe, to the need for an emergency plan for the materials license, as 2 curies of plutonium represents the threshold quantity in 10 CFR 70.22(i)(1) for a special emergency plan meeting the new regulatory requirements for high-risk materials licensees, or an alternative analysis demonstrating grounds for an exemption [grounds which are quite limited, pursuant to 10 CFR 70.22(i)(1)(i)]. But the Presiding Officer, three business days before this rebuttal was due, ruled that we are precluded from putting forward any

evidence on these matters.

15. We would have demonstrated that, based on the measurements available, 10 grams of NBL CRM 127 appears to be slightly in excess of the requisite 2 Ci threshold. We would have demonstrated that therefore, the Applicant was required to include in its application either the emergency plan meeting the special requirements for materials licensees or the analysis identifying unique circumstances within the restrictions of the rule that would exempt it from such a plan. And we would have demonstrated that it did neither, and thus was not in compliance. We would have further demonstrated that there is no question that the Applicant is 12.5 times over the parallel limit for americium, and has failed to provide either the emergency plan meeting the specific regulatory requirements or a valid dose calculation properly addressing the factors identified in the regulation and showing that doses in excess of 1 rem could not occur. We would have shown that the various calculations presented in the Applicant's affidavits to date do not meet the requirements of the regulation and cannot show compliance with the 1 rem limit if the regulatory requirements for such an analysis were complied with. And we would have shown that the pre-TRUMP-S, Part 50, reactor emergency plan, not submitted with the Part 30 and Part 70 amendment requests, cannot meet the new emergency planning requirements contained in those regulations for materials licensees. But we have been precluded from presenting any of what we had been preparing on any of these matters.

16. We state all this because we understand that, in the face of the Presiding Officer's belated Order forbidding this evidence a couple of days before it was due to be filed, a proffer is needed to preserve rights for subsequent review. But we also state this on a purely human basis, as a statement of dismay at a process which can require a panel of technical experts to work at breakneck speed for weeks to prepare rebuttal on matters the Presiding Officer has identified as key issues in the case, and then have him issue an order three business days prior to the due date that completely changes the rules of the game and the nature of the presentation we are to make. We must throw out half or two-thirds of what we were preparing, and rewrite the bulk of that which remains. Weeks of calculations about the 2 Ci must be discarded. Weeks of analyses about the validity of Applicant's claims about meeting a 1 rem dose in an accident, compared to the very specific requirements for such analyses given in the regulations, must likewise be discarded, and entirely new calculations, based on different assumptions and compared to different standards must be performed at the very last minute. We must work throughout the weekend before Christmas, at a time when it takes superhuman efforts just to reach all of the members of our panel because of the holidays, and even then we will be very lucky to finish by Christmas eve. The attorney for the Intervenors is unable to provide us the advice necessary during such a last-minute starting-over-again for our rebuttal, and he will not be able to see most of the new evidence until the morning it is due, so he is unable to integrate the factual presentation into his legal argument.

17. Now, we know that there are some who view the public's efforts to exercise its rights to participate in NRC licensing proceedings as an irritating aspect of the law that they wish would go away or could at least be ignored. Such people may find this last minute ruling requiring us to essentially start all over again with preparation of our rebuttal, just a few days before Christmas, and the refusal to extend the time for submission

of the rebuttal, all very amusing. But these are serious matters that are to be resolved by this proceeding, and a process with at least some semblance of reasonableness is not too much to ask for.

18. We are not naive about the system in which this entire proceeding is taking place. We understand that in the entire history of the NRC and its predecessor agency, the AEC, neither agency has ever denied a contested license. It does not take a genius to entertain the notion that, given that history, the outcome in this proceeding is similarly preordained. Furthermore, under Subpart L rules, the Intervenors are entitled to no discovery and have no right to a hearing where they can call or cross-examine witnesses. The NRC staff can do a cursory review of an inadequate application, grant it, and the applicant can do what it wishes to with the nuclear materials in question while the public "hearing" guaranteed by the Atomic Energy Act drags on trying to determine whether it is safe. The central issues in the case--whether the activity will do tremendous damage to international efforts to control proliferation and whether its stated goal of being able to dispose of 90% of high level waste in low level dumpsites wouldn't be an environmental catastrophe of the first degree--have been ruled irrelevant in the case and evidence about them forbidden.

19. We know all this, and have no illusions about the final outcome of this proceeding, at least before the NRC. But we nonetheless believe some simple human courtesy is not too much to expect, even with the structure we have just described above. And issuing an Order the Wednesday before Christmas, changing almost the entire nature of permissible rebuttal, and then insisting that the entirely redone rebuttal be submitted by Christmas eve, demeans not just the process, but the individual.

If the New Emergency Planning Rules Do Not Apply, What Requirements Do?

20. We believe that the Presiding Officer erred in his last-minute determination that because the new materials license regulations requiring special emergency plans for facilities with more than 2 curies of plutonium or americium became effective April 7, 1990, and because the University had applied for its license amendments in February and March and received them on or before April 5, they were exempt them from the effects of the new rules. The regulations, however, do not apply merely to applications, but to any licensee who is licensed to possess more than the threshold quantities after April 7, as is clear in the statement of considerations for the rule. The University's amendments were to permit possession of greater than threshold quantities for a long period after the effective date of the regulations, and they therefore had to at the time of their application and staff review--and certainly must now--show compliance with those regulations.

21. But the Presiding Officer has ruled to the contrary--the new emergency planning regulations for materials licensees do not apply to entities who applied for or were granted licenses prior to April 7, 1990. Let us suppose that the 2 curie thresholds of Pu and Am did not take effect until April 7, 1990, and that applications prior to that time did not have to be measured against the threshold. But what did they have to do?

22. NUREG-1140, the regulatory analysis for the new requirements, makes clear that pre-April 7 licensees are not exempt from emergency preparedness requirements:

> The questions is not whether licensees should have any emergency preparedness. That question was addressed long ago. The NRC has long required licensees to be prepared to cope with emergencies. The question is whether there should be additional requirements.
>
> p. 3, emphasis in original

23. Thus, the Applicant was--and is--required to demonstrate adequate emergency preparedness for accidents involving the requested nuclear materials, whether the application was submitted before or after April 7, 1990. Dr. Adam states in his original affidavit he did not evaluate the application for adequate emergency planning measures because he believed--which he now admits was erroneous--that the license application for 25 curies of unsealed americium (and which he granted) was for a quantity less than the 2 curie threshold he believed existed for emergency planning. But as NUREG-1140 makes clear, the 2 Ci threshold was merely for "additional requirements," and that it was settled "long ago" that materials licensees were required to have emergency preparedness measures.

24. The regulatory history of the new Part 30 and Part 70 emergency planning regulations in question make clear that they were to "codify the radiological contingency planning requirements set forth" in Commission directives in 1981 which required all materials licensees in excess of certain threshold quantities to establish Radiological Contingency Plans for incidents involving those materials. NUREG-0767 sets those thresholds--for americium-241 it is 0.3 curies; for plutonium-239, it is 0.1 curie! 46 FR 29712, 29714; 46 FR 2566.

25. So, even if you accept the new ruling by the Presiding Officer that the new 10 CFR 30.32(i) and 70.22(i) emergency planning requirements didn't take effect until after the grant of the application, and that the application is not still pending, despite the current proceeding regarding it, then the old emergency planning requirements were still in effect and had to be complied with. And those thresholds were even stricter, and there is no question the Applicant was way above those thresholds (>80 times the threshold of americium, >5 times the threshold for plutonium.) And those requirements do not provide any alternative method of getting exempt from the requirement for a Radiological Contingency Plan tied to the materials requested by performing an alternative analysis. (The Presiding Officer is reminded that Rockwell, the original sponsor of the TRUMP-S project, had to submit a Radiological Contingency Plan for TRUMP-S as part of its license application; that that RCP was the focus of much of the litigation before him in the Santa Susana case; and that an RCP was required thus for materials license applications submitted prior to the April 7 1990 date in which 10 CFR 70.22(i) and 30.32(i) supposedly took effect.)

26. One way or another, the University of Missouri should have submitted an adequate emergency plan designed for dealing with emergencies associated with the unsealed transuranics it was requesting, and the NRC staff should have evaluated the adequacy of such a plan. The University has not even claimed it has submitted a Radiological Contingency Plan for the TRUMP-S

materials; no RCP is included in the application; none was evaluated by the NRC Staff. Neither the Applicant nor the NRC staff met the legal requirements for proper issuance of the requested license amendments; that issuance is null and void.

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27. We raised a number of points in our October declaration. Most of them have been essentially confirmed by Applicant and NRC Staff.

a. Applicant was in error when it stated in its application that the material requested was 94.42% Pu-239, 5.58% Pu-240, and that the maximum activity of the samples would be .71 mCi. Significant quantitites of Pu-241 and Am-241 were not identified, and the activity is nearly three times as high as the licensed limit--approximately 2 Ci, rather than .71.

b. The NRC staff official who approved the application--without performing either an independent safety or environmental review, nor any review of the existence of nor adequacy of any possible emergency plan for the unsealed transuranics requested--was in error in asserting in a sworn affidavit that the amount of americium requested was below the threshold he cited as requiring an emergency plan.

c. The applications neither contain nor specifically reference an emergency plan or radiological contingency plan meeting the requirements in effect either before or after April 7, nor is there an alternative analysis provided in the applications. (Since the Presiding Officer has now ruled that 10 CFR 30.32(i) and 70.22(i) do not apply, the Applicant no longer has the option of performing such an analysis to attempt to get exempted from the requirements of having a satisfactory Radiological Contingency Plan.

d. The applications have not been amended to remedy any of these defects.

e. The licenses provided to the Applicant give it permission to possess so much unsealed transuranics that it is in the top 0.1% of the 21,000 materials licensees in the country in terms of the dangers it poses to the public. 99.9% of these licensees pose less risk than does TRUMP-S, according to the NUREG-1140 ranking.

28. In what follows we discuss certain other matters raised in our initial report and responded to by Applicant. These include matters related to release fractions, the lack of a safety analysis report in the applications, the accident analysis "summary" presented by Dr. Morris on 30 May, the HEPA filter issue, and the adequacy of precautions against and preparations for a fire that could put at risk the transuranics in question. Much of the Applicant's case consists of bits and pieces of accident consequence calculations, each contradictory to the other. We do not know if the University intends a single one, or some combination of these affidavits, to stand in for the safety analysis that should have been included in the

original application. To the extent that they purport to be the alternative analysis assertedly demonstrating doses below 1 rem, authorized in 10 CFR 30.32(i) and 70.22(i), we have been precluded by Judge Bloch's Wednesday Memorandum and Order from presenting evidence demonstrating that they do not meet the requirements specified in those regulations. We state here, however, that we had been preparing such demonstration, and had we not been precluded by the presiding officer's order from putting it forward as evidence, would have herein demonstrated that each and every accident and dose calculation presented in the Applicant's affidavits fails to meet the requirements of the regulations for such an alternative dose analysis and, when the errors are corrected, fails to demonstrate doses below 1 rem.

The Applicant's Failure to Accurately Identify Curie Limit and Isotopic Content in its Application

29. The license amendment request by the University of Missouri-Columbia for special nuclear material (SNM), dated February 20, 1990, requests 10 grams of unsealed plutonium, for an asserted total of 710 mCi, and identifies the isotopic composition as 94.42 wt% Pu-239 and 5.58 wt% Pu-240.

30. As we pointed out in our October declaration, this is not correct. Plutonium generally will contain a substantial quantity of plutonium-241 and, depending upon the age of the sample, americium-241, its decay product. The total activity will be substantially greater than 710 mCi.

31. The University has now indeed admitted that 10 grams of the kind of plutonium it possesses would contain approximately 1.2 curies of plutonium-241 and about 70 mCi of americium-241, in addition to the 710 mCi of other isotopes they had initially identified. The total curie content of the material for which they have requested a license is thus about 2 curies, not the .71 curies claimed in the amendment application, and it contains in significant quantity several isotopes not described in the application.

32. The University now admits that in addition to 584 mCi of Pu-239 and 126 mCi of Pu-240, 10 grams of CRM 127 includes approximately 1.2 curies of plutonium-241 and 70 mCi of americium-241. It now argues, however, that it did not need to include those either in the listing of isotopes or in the total curie limit because they are allegedly "trace contaminants." This is a serious misuse of the term. "Trace" generally applies to radioisotopes that are less than 1% of the total activity of the substance. In this case, plutonium-241 represents approximately 60% of the total activity, and 170% of the total activity asserted by the University in its application. The 70 mCi of americium represents approximately 10% of the activity reported by the University, the radiological equivalent of having 11 grams of Pu-239 and -240 when they asked only for 10.

33. 10 CFR 70.22(a)(4) requires applications for licenses and license amendments to possess special nuclear material to identify:

> The name, amount, and specifications (including the chemical and physical form and, where applicable, isotopic content) of the

special nuclear material the applicant proposes to use or produce.

34. It is our professional opinion that the University did not comply with this requirement in its February 20, 1990, application. Neither the amount (approximately 2 Ci rather than the requested .71 Ci) nor the true isotopic content (14 mCi Pu-238, 584 mCi Pu-239, 126 mCi Pu-240, 1210 mCi Pu-241, and 72 mcI Am-241, according to Dr. Morris's affidavit of October 29) were accurately identified in the application. (Dr. Morris now reports $< 1 \times 10^{-6}$ curies of Pu-242, but that amount is sufficiently small that we would consider it trace and not necessary to report.) Ten grams of the plutonium sample in question would contain nearly three times the maximum licensed activity requested by the university or authorized by the license granting the application, and it would contain in significant quantities two isotopes not identified in the license application.

35. Regulatory Guide 10.3 states:

> The special nuclear material requested should be identified by isotope; chemical or physical form; activity in curies, millicuries, or microcuries; and mass in grams. Specification of isotope should include principal isotope and significant contaminants. Major dose-contributing contaminants present or expected to build up are of particular interest. For example, the quantity of plutonium-236 present in plutonium-238 should be specified.
>
> Possession limits requested should cover the total anticipated inventory, including stored materials and wastes.

36. It is our professional opinion that the University did not comply with this guidance in preparing its application. Only about one-third of the activity in "curies, millicuries, or microcuries" was identified--.71 Ci instead of approximately 2 Ci. Only one (Pu-240) of the three significant contaminants (Pu-240, Pu-241, and Am-241) were reported.

37. We understand that the University is claiming that the 1.2 curies of Pu-241 and 72 mCi of Am-241 are not significant contaminants in a sample of 710 mCi of Pu-239 and -240. This seems to us unsupportable and a post hoc rationalization of a failure to specify accurately the total curie content and the significant isotopes contained in the sample.

38. We understand further that the University is arguing that the statement "Major dose-contributing contaminants present or expected to build up are of particular interest" exempts them from having to identify the Pu-241 or Am-241. This requires a misreading of the full passage, we believe, which makes clear that total curie content needs to be identified, as well as the primary isotope and significant contaminants (which we would describe as anything at least 1% of the total activity). But the passage goes on to indicate that even if a contaminant is not significant in amount, particular interest should be paid to small contaminants that may nonetheless be significant to dose, i.e. may become significant to dose due to buildup. The example given of Pu-236 in Pu-238 is instructive, because standard Pu-238 samples at manufacture may represent only on the order of 5×10^{-5} wt% Pu-236, which would at first glance not appear to be a potential significant dose contributor, but because of its high specific radioactivity (about

10,000 times that of Pu-239), may in the first years after manufacture make a contribution to dose. Likewise, significant dose-contributing isotopes like americium-241, which build up over time, need to be identified, even if at the time of acquisition of the sample, there is a relatively small amount present. Thus, the quoted passage of the reg. guide requires all except insignificant contaminants to be identified, and [illegible] for those, they should be if they can contribute to dose. The Pu-241 and Am-241 are significant contaminants and should have been identified. Their curie count should certainly have been included in the licensed activity limit. To not do so means the facility is not licensed for the material, which has three times the licensed limit of activity and two significant contaminants not identified.

39. But even were one to take the University's misreading of the regulatory guide, and were one to take into account dose, the unidentified Pu-241 and Am-241 do not constitute "trace contaminants." As indicated in paragraph 4, the Pu-241 represents 170% of the activity identified in the application, and the Am-241 represents 10%. Even using Dr. Adam's correction factor of 45 for the different MPC's for Pu-241 and Pu-239/-240 (Adam affidavit of 5 December, p. 3), nearly 4% of the dose from the requested material would be coming from Pu-241, certainly not what we usually call a "trace contaminant," even when relative dose effectiveness is taken into account. And since the dose effectiveness for Am-241 is the same if inhaled as for Pu-239/-240 (in fact, slightly larger, 530 Rem/Ci vs. 510 for Pu-239, according to NUREG 1140, p. 80), it constitutes 10% of the dose from the sample; again, certainly not a "trace contaminant."

40. Compare the information included in the application with what the University now has admitted, after we pointed out the problem:

Application

Total mass	10 grams
Total curie limit	.71 curies
Isotopic composition	94.42 wt% Pu-239
	5.58 wt% Pu-240
for a total of 100%	

Applicant now admits 10 grams would contain
(from Morris affidavit, p. 7, and attachment 6-4)

Total curie limit ~2 curies

Isotopic composition

14	mCi Pu-238
584	mCi Pu-239
126	mCi Pu-240
1210	mCi Pu-241
72	mCi Am-241
2006	mCi

41. Even were one to correct for the lower dose effectiveness of the Pu-241, one gets:

14 mCi
584
126
27 (1210/45)
72

823 alpha-dose-equivalent mCi

42. Thus, even correcting for dose contribution, this is 16% higher than the 710 mCi the University said would be its curie limit in its application.

43. Thus the isotopes not identified in the application constitute together 180% of the actual activity and about 15% of the total inhalation dose hazard. In no way can these be considered "trace contaminants."

44. Additionally, because of the gamma activity associated with americium-241, its presence adds an additional hazard of direct exposure not found in the plutoniums that are primarily alpha emitters. Dr. Langhorst has made a big point of the fact that the americium is interspersed with the plutonium. Of course that is the case. But that in no way diminishes the importance of health physicists recognizing its presence, calculating accurately its quantity, and taking appropriate shielding precautions if necessary.

45. It seems clear that the University personnel either believed the Rockwell isotopic composition report of 100% Pu-239 and -240, or presumed, without checking, that the content of other isotopes was "trace," i.e., less than 1% of the activity. Either assumption would be wrong. Dr. Morris says they didn't include the content of the other isotopes in the application because it takes a lot of calculation which they only did after we raised the issue. But then the University had no way of knowing the americium content, for example, and had no way of estimating the necessary precautions against the copious gammas produced by americium. Likewise, the NRC staff says they know americium, plutonium-241, and other isotopes appear in plutonium, but if the amounts are not disclosed, and in particular if the activity is not included in the curie limit, then the staff has no way of assessing the safety and precautions of the Applicant's proposed activity. If the sample were reactor-grade, for example, the americium content would be very much higher and a much higher gamma dose would exist. But if the Applicant and Staff--neither of whom had calculated the content or accurately reported it--presumed it was essentially all alpha emitters with only a trace gamma emitter, then inadequate precautions would be taken and there would be an unnecessary risk to the public.

46. The Pu-241 and Am-241 content of the requested plutonium sample(s) should have been identified properly in the application, and the correct overall activity level--about 2 Ci, rather than the declared .71--should have been used. The University currently has more plutonium than it is legally licensed for, and possesses isotopes for which it has no license. Its staff should have known better than to list the curie content of 10 grams of plutonium as 710 millicuries, and it should have assessed the

plutonium-241 and americium-241 content to know whether it needed to take special precautions.

HEPA Filters

47. This matter does not need a great deal of additional discussion. The University's own expert consultant on alpha labs says it is a design defect to have the exhaust from the room and the exhaust from the glove box join in one ventilation line, and that the design has failed to follow accepted industry standards that there be two DOP-testable-in-place HEPA filters between any potential source of contamination and people who could be exposed. He rightly has identified a backflow situation where contamination on the face of the HEPAs could be transported into the alpha lab via a backflow event in the exhaust line. The February design for the glove box exhaust had two DOP-testable HEPAs in the exhaust line from the glove box, before it connected with the main exhaust line. The University removed one of those. And it put no HEPAs in the room exhaust line prior to the point where it joins with the exhaust line from the glove box. Mr. Steppen is right about the design flaws. The University agreed, ordered the additional HEPAs, found out it would take a license amendment and some additional time, while under pressure from Rockwell to complete experiments before September 30. So it cut corners and decided to go ahead with the neptunium experiments without the HEPA it itself had indicated on the check-off sheets was essential before startup. The IUS minutes referred to by Dr. Morris indicate none of the "analysis" he later reported; that appears a post hoc rationalization after the issue was raised by the Intervenors in their stay motion. All the IUS minutes say is that they were proceeding with the HEPA filters, a backflow situation could develop, but that it was felt OK to go ahead for a few weeks with the experiments on Np--a far less dangerous material than the upcoming Pu and Am--until the HEPAs arrived. Had the issue not arisen publicly, the HEPAs would probably be installed by now. But the potential for public embarrassment and the necessity of obtaining a license amendment should not prevent a design defect from being rectified.

48. Mr. Eschen, in his effort to help the University in its problem with Mr. Steppen, asserts that the "single-failure" criterion means one doesn't need to have redundant testable HEPA filters because it would require a separate failure for them to be needed. This misuses the "single failure" criterion, which assumes a design basis event, however caused (for example, a backflow event), and requires that the safety systems designed to protect against the consequences of such an event be redundant so that a failure of one of them will still leave one able to perform the required backup function. The University design violates this standard. Furthermore, NRC has gone beyond the single-failure criterion, requiring "defense-in-depth." For example, even with redundant emergency generators to protect against station blackout, power reactors are required to have containment structures, one more layer of defense against release to the public.

49. Mr. Steppen is right; the University was right to listen to him and order the additional filters; it was wrong to try to go ahead with the Np experiments before the new filters were added; and it is wrong to now refuse to install them as it works with the far more dangerous Pu and Am isotopes.

Release Fractions

50. Dr. Morris now seems to be claiming that his release fraction of 10^{-6} in his accident "summary" was meant to be a combination of two different 10^{-3} factors--one for amount of material made airborne, the second for the amount that escapes through an operational HEPA filter. NUREG-1140 says it is inappropriate to take credit for filters or stack releases, and assigns a 0.001 release factor for actinide metal in overheating situations without external fire and up to .007 if the material is involved in a solvent fire. NUREG-1140 says the figures it uses are "representative" of values found in various experiments, and repeatedly quotes Commission guidance to the effect that for emergency planning purposes, "realistic" instead of "conservative" assumptions should be used, as opposed to traditional NRC safety analysis inputs, where "conservative" assumptions are to be used.

51. Indeed, an examination of the literature indicates that the .001 figure used by NUREG-1140, and now apparently adopted by Dr. Morris for the release if the escape is not via HEPA filters, is an average value for numerous experiments under varying conditions. Condit at Livermore ("Plutonium Dispersal in Fire: Summary of What is Known", cited in our previous declaration) at Livermore plotted release fractions of respirable size from experiments reported in the literature and indicated that they varied over about six orders of magnitude, with the average value being about 10^{-3}. This was not from numerous experiments of the same conditions, producing varying results which were then averaged. This was from numerous experiments of different conditions, where the stress on the plutonium ranged from very mild to severe. In situations where plutonium metal was merely brought to a temperature of 600°C or so, permitted to start self-heating oxidation, and then had the heat removed, all with low air flow, low release fractions were found. These figures are at the lowest end of the measured values, the lowest values from the Schwendiman study Dr. Morris initially cited. When the air flow increases, the release fraction increases. When there is mechanical "tossing" of the contents, such as might be caused in a real fire where things knock around, the release fraction goes up. But these studies didn't involve plutonium in a fire in which other combustible material is burning. In those cases, release fractions go up to several percent when there are flammable materials burning nearby and up to several tens of percents when the plutonium is caught up in a fire involving combustibles burning. To average these various experiments is obviously inappropriate for conservative safety analysis attempting to estimate release fractions from a major fire involving americium and plutonium caught in a major fire involving significant combustibles, such as would be the case in the wood-frame alpha lab or a natural gas explosion in the MURR basement igniting all the combustibles and flammable materials such as hydraulic oil.

52. Dr. Morris cites the 1963 Hilliard paper for the conclusion that "no significant inhalation hazard would be produced at 200 yards and beyond as the result of burning several kilograms of the metal," a quotation also cited by Dr. Krueger. We don't believe any responsible radiation safety expert would make such a statement today. Indeed, Dr. Roger Batzel, at the time director of Lawrence Livermore National Laboratory, testified before Congress in 1988 that a fire involving the few kilograms of plutonium metal in an atomic warhead "could be probably worse than Chernobyl." (Energy and Water Development Appropriations for Fiscal Year 1988, Hearings before a

Subcommittee on the Senate Appropriations Committee, 74-239, p. 1135-6). Hilliard was most likely referring to inhalation causing acute radiation syndrome (e.g., leading to death within a few days or weeks), in which case the statement is perhaps correct. But to the extent that one is concerned about inhalation leading to cancer years later, one would not want to be a few hundreds yards from a few kilograms of burning plutonium.

53. Interestingly, Dr. Morris and Dr. Krueger do not quote the actual release fraction measurements cited by Hilliard. Those measured values show 1% released in a half hour from plutonium suspended above--but not in--a gasoline fire and 3% released in a similar setup but with the temperature increased slowly to a maximum of 600° C. The 3% figure is precisely the number we had discussed in our previous declarations and to which the University took such exception, citing Hilliard supposedly in support of their attack on Hilliard's own number.

54. The Seehars study cited originally by Dr. Morris in asserted support of his 10^{-6} release fraction (he claimed it showed a maximum release fraction of 5×10^{-5} for open air burning) actually showed releases of between .005% and .12% (he picked the smallest number again) for a four minute sampling time, creating an hourly release fraction of roughly up to 1.8%. But instead he used .005%. This has led to the questions of whether he had seen the study prior to relying on it, or had just used Rockwell's characterizations of it in the Santa Susana case, as he appeared to have with the Schwendiman study, and whether he read the full study. Dr. Morris now claims he knew all along that the measurement was for a four minute fire, and claims he purposely picked that because that is the maximum credible length of a fire he believes should be assessed for a conservative safety analysis. It would appear more likely that Dr. Morris did not have the study when he made his original "summary," and relied on Rockwell's representation of it. His presentation to the community forum in late May when he cited the study certainly would have given no listener the understanding that he had picked the lowest release fraction and for a maximum fire of four minutes.

55. Scaling the results of the Seehars study to a more realistic length fire brings a maximum release fraction of 1.8%-2.4%/hr (he reports elsewhere a 4 minute release fraction of .16%). (The sample size used in the Seehars 4 minute experiments are comparable to the mass of the samples used at MURR--a fraction of a gram to a few grams). That roughly linear scaling is not inappropriate is evidenced by the fact that Seehars also reports the results of a 25-minute burning experiment, in which the release reported is 2.025%, for an hourly rate of nearly 5%. This--and the Hilliard data cited above--suggests that if anything, release rates increase with time of fire. And as Captain Wallace indicates, realistically, a fire at MURR could last several hours.

56. The original Schwendiman study cited by Dr. Morris (and Rockwell) involved mere overheating plutonium metal with no external fire. The authors said that what was needed to do next was see the release fractions if the material were involved in a fire caused by combustibles or flammable materials burning, providing a driving force for the release of the radioactivity. And it is this study which is the most important, yet it is not cited by the University.

57. Mishima and Schwendiman, in a paper entitled "The Amount and Characteristics of Plutonium Made Airborne Under Thermal Stress" (cited in our October submission, placed small quantities of uranium dioxide (used as a less dangerous simulant for plutonium) on small quantities of ordinary combustible materials such as Kleenex, cheesecloth, and cardboard, and ignited them. Releases of up to 55% were observed in flames lasting from one to a few minutes. For example, in a 3.7 minute flame involving 10 grams of Kleenex and a fraction of a gram of uranium oxide, 40% of the uranium was entrained; in a 6 min. flame involving .24 g of U on the same amount of tissue paper, 36% was entrained; a 3.5 minute burn with .11 grams on tissue paper produced a 55% entrainment. The figures for 10 grams of cheesecloth and varying amounts from .12 to 3.6 g of U are similar: releases of 35%, 44, 37, and 10% for the oxide. When U was place on 10 grams of corrugated cardboard, releases of the oxide ranged from 2.4% to 12% to 8.3% to 20%. When wastes were combined (5 grams cheesecloth + 3 grams tissue paper in a polyethylene bag sealed in a small corrugated cardboard box with masking tape), the release of the oxide was 12.5% and 17.6% in flames of duration of 4 and 6 minutes respectively.

Mishima and Schwendiman concluded that releases under such circumstances are such "that to a first approximation half of the active material may be considered to be entrained. A conservative position would be to assume that all such material would be airborne." (emphasis added).

59. (It should be remembered that when transuranic metals are burned, they produce fine particulate oxide. In a major building fire, releases would occur from both the oxide driven off as the metal burns and the subsequent entrainment by the building fire of the oxide that remains behind.)

59. It is clear from the literature that for a situation in which the plutonium or americium is not merely being overheated without any external fire under relatively quiescent circumstances, but rather is involved in a fire involving combustible or flammable materials burning, not for 4 minutes, but for an hour or several hours, as would be the situation in the real world in a normal building fire involving the MURR basement where the alpha lab and archived actinide storage are located, releases of many tens of percent must be assumed.

What Should Be Assumed About the Maximum Inventory that Could be Involved in Such a Fire?

60. NUREG-1140 rightly assumes that if the material is stored or used in the same building, one must assume that in the worst case all is available for release. A generalized fire could do so. The fact that the full inventory must be taken to the alpha lab for separation of the the smaller quantities also means that the full inventory is repeatedly in the alpha lab. The full inventory is also available for release should a fire break out where it is stored (we note other items stored in the same room are stored in highly flammable parafin, for example). Over time, much of the material will be in "archived storage," in a filing drawer in the wall near the alpha lab. The actinides are stored in this lead-lined drawer inside aluminum vials. Lead melts at 328°C and aluminum at 660°C; Captain Wallace has pointed out the extreme temperatures reached and sustained in basement

fires, of 2000-3000°F more than enough to melt the lead and to destroy the integrity of the inerted aluminum vials containing the americium and plutonium samples, which would then be exposed to air and intense heat and the convective forces of the raging fire. Even though the storage drawer is rolled into a slot in the wall, in a worst case scenario, the face of it would experience intense heat in the fire, melting the lead and transferring the heat throughout the drawer reaching the integrity of the aluminum vials and exposing the americium and plutonium. Additionally, periodic materials audits mean that at frequent intervals most or all of the material will be routinely exposed anyway.

61. Furthermore, the waste materials containing the transuranic materials must be stored at the University until DOE takes them back for disposal. Since there is currently no place in the country that can take TRU wastes, they may be stored for a long time at the University awaiting final disposition, long after TRUMP-S is over. They will thus be continually vulnerable to fire. This is also true for the contamination in the alpha lab that the University is required to commit to assuring funding for decommissioning. The fact that the University has not informed the legislature of the need for nearly $2 million to decontaminate MURR after TRUMP-S is completed, and the fact the the Missouri Constitution prohibits the kind of assurance of future funding that the NRC asks MU to provide, means it is quite likely that decommissioning of the alpha lab at the close of the work will be put off many years. It is very hard for Deans to come up with money to clean something up when there are pressing needs for new faculty, buildings, and research projects. It is our experience that university nuclear facilities often take far longer to get decommissioned than planned because of the difficulty Deans have in the real world getting the money necessary to do it. It is always easier to just put it off a few more years. Which means a few more years of risk of fire, during periods where safeguards are likely to have eroded substantially due to the completion of the original project. Because of the commitment to store the wastes until DOE figures out where to put them, and the failure to make hard and fast commitments about where the funding will come from for decommissioning the alpha lab, it would not be unreasonable to expect the period of vulnerability while these actinides are at risk at the University to extend ten or fifteen or even twenty years beyond the several years of TRUMP-S work already planned.

62. Because of these various factors, a conservative safety analysis must, we believe, assess the potential impacts of accidents involving the full inventory requested in the license amendment requests.

Should One Assume a Stack Release in Case of An Accident Where the Emergency Procedures Say Secure the Stack in Case of Accident?

63. NUREG-1140, upon which the University attempts to rely so much, says one should calculate releases in an accident based upon ground-level releases and no filtration. Reg. Guide 1.145 indicates one can only take credit for a stack release when one can guarantee that in any conceivable accident the stack will function and be the only point of release.

64. This matter is really rather silly. The University's own emergency procedures (see FEP-3A) for dealing with a fire involving the alpha lab are

to shut the ventilation system down and close its dampers. With such a procedure--proper because you don't want to either feed the fire or purposely expel radioactive material into the environment--it is absurd to also assume for accident analysis purposes that that is indeed how the release occurs.

65. Even if the procedure weren't to close down the exhaust system, the smoke would rapidly clog the filters. They would lose their effectiveness at removing radioactive particulates as soon as they were saturated with soot; air flow would be prevented; either other unfiltered pathways would be found or the filters would be blown out or catch fire.

66. The University has also argued that the smoke and radioactivity will somehow stay inside the building. This defies the laws of fluid flow. Fires occur all the time in buildings. Smoke pours out from numerous penetrations at ground level--it doesn't stay contained within the building. Fires pressurize buildings, and expanding gases will seek pathways for release.

67. It is simply unrealistic to assume that in a serious building fire in that basement, significant smoke (and radioactivity) would not escape as a ground level release.

68. One other comment. It has been argued that the nearest anyone would be to the building is 100 meters. People will get as close to a fire as the cordoned-off area allows. They will congregate at that line. The emergency plan and fire response plan, such as they are, do not identify when, and if so, out to what distance, an enforced exclusion zone will be provided. People often breathe substantial amounts of smoke at scenes of fires--rushing around trying to find friends and loved ones, getting as close as they can for the excitement, etc. There is something about fires that attracts crowds.

69. Additionally, for fires with the lower release fractions used by the University (e.g., .001), which are for oxidizing plutonium metal with no external fire, there is no true smoke produced. One could stand quite close to the release point and not know that plutonium or anything else was coming out.

LIKELIHOOD OF FIRE

70. Fires are high probability events. They occur so frequently that we build fire stations every few miles to provide response to the fires that occur in the neighborhood nearby. These fire stations are kept quite busy.

71. The University has argued that a fire at MURR is so unlikely as to be noncredible. Their primary basis for arguing this is the impression that they try to give that there are few if any combustible or flammable materials in the alpha lab and surrounding building, and that the basement is made out of concrete. As Captain Wallace has indicated in his declaration, a careful reading of the disclosed fire loading indicates it is substantial, and the fire risk likewise substantial. As he indicates, the alpha lab itself is not, as claimed, built of non-combustible materials, but

is constructed of a large quantity of wood. It is essentially a small wood-frame house built into a concrete oven, as he puts it, which will both elevate the temperatures of a fire very much and make fighting it very hard. And, as he indicates, the construction of the alpha lab in a basement goes against NFPA recommendations, as does the apparent lack of automatic sprinkler protection.

72. It must be concluded that over the prospective decade or two during which the TRUMP-S materials may be at the University, a serious fire is a significant probability. And the decision to construct the alpha lab of combustible materials, and place it in an unsprinklered basement contrary to NFPA standards, makes both the likelihood and consequences considerably higher.

DISPERSION

73. Dr. Langhorst in her affidavit of 13 November (Licensee's Exhibit 2) has inquired about the nature of the dispersion model we employed in our previous declarations and the assumptions used.

74. For dispersion at 100 meters and beyond, we used the standard NRC Regulatory Guide for estimating atmospheric dispersion from nuclear accidents--Reg. Guide 1.145. We checked our results against the dispersion model recommended in ANSI/ANS-15.7, the American National Standard Institute/American Nuclear Society national standard for site evaluation for research reactor facilities. The results coincided closely.

75. We used the standard NRC meteorology to be used in accident analysis, F class stability and 1 m/sec windspeed, what NUREG-1140 (p. 10) calls "the traditional NRC assumptions."

76. We used the standard NRC X/Q of 8.65×10^{-3} sec/m^3 at 100 meters, taken from Reg. Guide 1.145 . This is less conservative than values used in a number of other sources. NUREG/CR-2079 (p. 48-9) and NUREG/CR-2387 (p. 42-3), NRC accident analyses for Argonaut and TRIGA research reactor facilities, use a value of 1×10^{-2}, with the latter report also using a value of 1.5×10^{-2} at 100 meters, derived from the WRAITH computer code). NRC Reg. Guide 1.4 gives the X/Q for releases of 0-8 hour duration as 1×10^{-2} at 200 meters, twice the distance for which we use it, indicating considerably higher values at 100 meters than we employed. The University of Florida's Safety Analysis Report used that same value for the same time period at ~.1 miles (~160 meters), again indicating higher values at 100 meters. Rockwell, in its Radiological Contingency Plan for the TRUMP-S project when planned for Santa Susana, states that it employed a X/Q of .16 s/m^3 at 300 meters for a ground level release, which it compared to "typical X/Q values" of 5×10^{-3} at the same distance. (Rockwell International Corporation's Responses to the Intervenors' Concerns Pertaining to the SNM-21 License Renewal, Docket 70-25, 19 April 1990, see p. 13 and Rockwell Exhibit 1-1.) In either case, a X/Q at 100 meters considerably larger than we employed would result.

77. Thus, the X/Q we used is less conservative (i.e., more optimistic) than

the values that are used in Reg. Guide 1.4, NUREG/CR-2079, NUREG/CR-2387, the University of Florida's Safety Analysis Report for its nuclear facility, or that employed by Rockwell in its Radiological Contingency Plan or its alternative less conservative, more "typical" figures . It is, however, the X/Q used in Reg. Guide 1.145 for atmospheric dispersion analyses in accidents, and so we used it, recognizing that the use of more conservative X/Q values suggested by the literature could result in higher estimates of radioactivity concentrations than those we calculate using Reg. Guide 1.145.

78. The calculations we performed, using the Reg. Guide 1.145 methodology, correct for building wake effects and plume meander, as required by the Reg. Guide. [We note in passing that Mr. Osetek in his affidavit (Licensee Exhibit 1), correctly indicates that "NRC Regulatory Guide 1.145...describes the use of plume meander models" for low wind speeds such as those assumed in NRC accident analyses. However, rather than model the meander, using Reg. Guide 1.145, he instead increases the wind speed by a factor of 4.5.]

79. Dr. Langhorst, in her affidavit, questioned the figure we used for the volume of MURR basement through which the radioactivity released in the accident would diffuse before being released to unrestricted areas outside. We must preface our response by noting that we had repeatedly asked the University and the Presiding Officer for such information about site characteristics, as it is important to accident consequence estimation, but the former has declined to provide it and the latter has declined to direct such information about MURR be included in the hearing record. We have complained about how this failure to make available necessary information impairs the ability of the technical experts assembled by the community groups participating in this proceeding to conduct an adequate review, but so far, to no avail. We note further that this is the kind of information that should have been in the application in the first place. Without such information, neither an outside reviewer nor the NRC staff reviewer could perform an adequate safety review of the proposed project. [We further call attention to the inadequacy of the only sketch of the MURR basement where the alpha lab is located, which is not drawn to scale (see "no true scale" label in the application, Figure 1, "Alpha Laboratory Location Plan; Basement Level - Research Reactor.")]

80. Without access to site specific information, we estimated this volume in our calculations as 1500 m^3, based on similar dispersion calculations we had presented in the UCLA research reactor license renewal proceeding before the NRC and a brief examination of the exterior of the MURR facility by two of our panel members in July. Dr. Langhorst states that the relevant volume is approximately 1400 m^3. We would like to see the actual basis for that figure, but note that it is remarkably similar to the estimate we had used in our calculation. The difference, we should note, is once again in the non-conservative direction; i.e., our use of a slightly larger starting volume into which the radioactivity must diffuse before release outdoors results in our understating the concentrations at the release point and beyond.

81. Reg. Guide 1.145 starts at 100 meters (presumably because the facilities for which it was designed had exclusion zones considerably larger than that.) To estimate concentrations from the point of release into unrestricted areas up to the point where Reg. Guide 1.145's model could be used, we employed the Halitsky model (Halitsky, J., "Gas Diffusion Near

Buildings", ASHRAE Trans. 69, #1855, pp. 464-485, 1963; cited also in Hosker, R.P., Jr., "Methods for Estimating Wake Flow and Effluent Dispersion Near Simple Block-like Buildings", NUREG/CR-2421, ERL-ARL-108, 1982, p. 36; and in Li, W.W., Meroney, R.N., Peterka, J.A., "Wind Tunnel Study of Gas Dispersion Near a Cubical Model Building", NUREG/CR-2395, 1982, p. 3ff). These results coincide closely with those obtained for concentrations at <100 meters UCLA derived using the separate model it employed in its Hazards Analysis for the UCLA Research Reactor, Application for Renewal of License for a Research Reactor Facility, 28 February 1980, Docket 50-142, p. III/B-6.

82. Dr. Langhorst has identified what she believes is roughly a factor of 30 difference between the concentrations that we calculate and those which she believes are conservatively appropriate. She states, first of all, that the concentration inside the building, diffused through 1400 m^3, is 1/26 as large as what she believes we have estimated as the concentration 1 meter from the building. (Langhorst affidavit, paragraph 39.) Second, she states that the X/Q value she has estimated we must have used is, according to her, 30-90 times those associated with the most conservative values in NUREG--1140. Lastly, based on the X/Q she believes we must have used, she estimates we must have presumed a windspeed of 0.041 to 0.095 m/sec.

83. As indicated above, however we used the standard NRC X/Q and the standard NRC windspeed.

84. So what is the source of the factor of the supposed 30 or so disagreement between Dr. Langhorst and ourselves? It does not really exist. The X/Q values and windspeed figures used by Dr. Langhorst and ourselves are in fact fairly comparable. The confusion arises from a misreading of our data, contributed to by less-than-clear language in our description of it. Dr. Langhorst presumed that the concentrations given apply to a release of 1 gram of plutonium, multiplied by .03, i.e., with a release factor already taken into account. Instead, the table was intended as a template to be used to scale accident consequences up or down, depending upon the assumption of amount of material involved and the release fraction used. The user of the table was to adjust its values up or down depending upon the combination of release fraction and starting quantity of material assumed. We had discussed a release fraction of .03, and extrapolating from the table indicated that concentrations over the Emergency Action Level would exist out beyond a mile using that fraction and a starting quantity one tenth of the licensed limit. Larger release fractions would produce larger concentrations; smaller fractions would result in smaller concentrations. And use of the full 10 gram licensed limit would increase concentrations proportionately; use of a quantity less than a gram would decrease it proportionately. The table was to provide a touchstone that a user could use to perform what variation analyses s/he wished depending upon input assumptions about release fractions and starting inventories. We recognize that this was not expressed clearly, and regret the confusion it may have caused Dr. Langhorst.

85. When she mistakenly says that we assumed a X/Q that is 30 times higher than the most conservative one from NUREG-1140, that is because she assumed the values in the table were based on 33 times less plutonium than they were. (The same confusion is the prime source of the factor of 37 difference Mr. Osetek says he gets with our estimates; Licensee Exhibit 1,

p. 10). And when Dr. Langhorst says the concentration inside the basement is 26 times the amount she thought we had calculated one meter outside, it is for the same reason. Indeed, her calculation and ours match very closely: the concentration we get one meter away, scaled for the same assumptions about starting quantity and release fraction, would be about 80% of that which she has calculated for the release point inside the building,

86. Let us see now whether, with that confusion cleared up, some areas of agreement can be identified. Let us for the moment leave aside two issues: what is the appropriate release fraction for the maximum credible accident and what is the starting amount of actinide available for release in the maximum credible accident. These matters are touched on elsewhere. Let us now see, using standard dispersion models for accident analysis, what the concentrations would be given different assumptions about these two factors.

87. The attached graphs and tables perform such a sensitivity analysis. With so many variables (distance, inventory at risk, and release fraction), it is clear that a single table could not represent the range of accident consequences without unnecessarily confusing the reader. We have thus produced six graphs, with a data table for each graph.

88. The graphs and tables are for the two primary transuranic elements of concern: plutonium and americium. Dispersion for accidents involving each element is calculated at various distances for three starting quantities of material: the licensed possession limit, the licensed in-process limit, and the Applicant's asserted normal process quantity. For each of these three cases, for each element, concentrations are calculated at various distances for a range of release fractions: the NUREG-1140 figure for overheating incidents involving plutonium metal without an external fire (.001), the NUREG-1140 figure for solvent fires involving actinides (up to .007), the 1% release figure used by DOE and found in the VIXEN experiments, the 2% figure found in a 25-minute fire by Seehars, the 3% figure found in an hour fire by Hilliard, the 10% fraction found in a number of experiments by Mishima, and the 30-40-50% fractions found in numerous other tests by Mishima. These last tests led Mishima to conclude: "Releases are such...that to a first approximation half of the active material may be considered to be entrained. A conservative position would be to assume that all such material would be airborne." (Mishima and Schwendiman, "The Amount and Characteristics of Plutonium Made Airborne Under Thermal Stress," BNWL-SA-3379.) This "conservative position" thus represents the top curve on the graphs.

89. We have discussed these release fractions elsewhere. And elsewhere we discuss what maximum quantity of the licensed material should be presumed to be at risk in the maximum credible accident. Here we present the concentrations at various distances, measured against established safety standards, given a range of input assumptions. They demonstrate that for most of the variations considered, concentrations of americium or plutonium in unrestricted areas would exceed permissible levels by a substantial amount. This is true in all the cases examined for americium. [Please note that for the first two graphs for americium (7.3 grams and 1 gram), the concentrations so exceed permissible standards that two of the more restrictive standards are not shown as they fall beneath the x-axis.]

90. [We should also note that when we compare concentrations inhaled in an

accident and compare them to concentrations based on annual limits on intake, we have made the appropriate corrections. In other words, we are not comparing a one hour exposure against limits that apply to continuous exposure at that level for a year. We have multiplied the standard for constant exposure over a year by 365 days a year times 24 hours per day. A person breathing that concentration for one hour of an accident would thus exceed the maximum permitted to be innaled in an entire year.]

91. The data also demonstrate the unsuitability of the site. The American National Standards Institute/American Nuclear Society national standard for research reactor site evaluation establishes maximum exposure limits for the nearest urban boundary. If a safety analysis indicates an accident at such a facility could cause exposures in excess of those limits at the urban boundary, the site is unsuitable. The urban boundary in the TRUMP-S case (only a half mile from the facility, many times closer than was the case in the Rocketdyne case, where even that larger distance was viewed as insufficient) is clearly too close to the site for most of the accident variations examined.

92. Americium is clearly the limiting case. Concentrations so far in excess of permissible are found that it is clear that even were one to assume a fully functioning HEPA filter and a stack release--which are totally unreasonable assumptions, for the reasons detailed earlier, not least of which is the emergency plan to shut off the stack in case of accident--concentrations in excess of acceptable standards are found for most combinations of reasonable release fraction and starting inventory.

93. But the release is by far most likely to be a ground release, and one is required by normal rules of conservative safety analysis to so presume.

94. One brief comment about safety analysis is in order at this point. Safety analyses are supposed to be conservative--i.e., they are to provide high confidence that one has bounded the potential accident impacts, given the fact that much about accidents is by definition unpredictable. NUREG-1140, so much discussed, was a regulatory analysis to determine whether additional emergency planning requirements should be imposed on certain licensees. It repeatedly stated its mandate was to perform a "realistic" analysis, as opposed to conservative[1], citing a Commission policy directive

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1. There is a third way of performing accident analyses--other than either traditional conservative approach the NRC requires for safety analyses and the "realistic" approach it mandates for assessment of the need for additional emergency planning regulations. And that is what Mr. Osetek calls his "best estimate," which we would suggest is simply another way of saying his most optimistic guess. Whereas NUREG-1140 looks at what it defines as an average accident, attempting to balance conservative and optimistic assumptions, and whereas traditional safety analyses attempt to bound the most serious credible accident, Mr. Osetek's "best estimate" attempts to remove as many conservatisms as possible and replace them with sufficient optimistic assumptions as to produce estimated effects that are inconsequential. It is not an accepted approach to safety analysis, and clouds the objective assessment of potential for public harm.

to that effect for preparing emergency planning regulations. In this regard, NUREG-1140 strove to be "realistic" by using some conservative assumptions and some non-conservative ones (e.g., focusing on the adult, not the most sensitive individual, the infant or fetus; using 24-hour average breathing rates, when one breathes in half of one's daily air in the 8-hours of normal activity; and a number of other nonconservative factors.) It used "representative" release fractions, as we have seen, i.e., the average of low figures from mild thermal stresses and higher figures from experiments more indicative of severe fires. And it took a non-conservative approach to estimating the maximum "intercept fraction." Although the University appears to think that NUREG-1140 did dispersion calculations and calculated inhalation concentrations through some sophisticated model, in fact NUREG-1140 and the associated Federal Register notices make clear that for inhalation, NUREG-1140 merely assumed a maximum intercept fraction of 10^{-6}, rather than calculating dispersion. The CRAC-2 code was used to calculate external doses, but internal exposures were done by this rule of thumb, rather than standard dispersion models. The source cited for this rule of thumb is a somewhat tongue-in-cheek article by Brodsky asking whether "10^{-6} is a 'Magic Number' in Health Physics?" He looks at a whole range of issues--resuspension factors, probability of accidents, release fractions from reactor accidents--and muses that the numbers frequently used are often on the order of 10^{-6}. Nowhere in the article, or in the earlier one touching on a similar subject that he also cites, does he make the claim that the maximum intercept fraction is 10^{-6} at 100 meters. Indeed, his conclusion is that the following "may be assumed to usually remain 10^{-6}" and goes on to list five different phenomena, one of which is "The fractional amount of material released from a building that will be inhaled by someone 800 m away, even under the most severe hypothetical conditions." That is a far cry from a maximum 10^{-6} intercept fraction at 100 meters. To the extent one can extrapolate from Brodsky's tables and figures, the intercept fraction he proposes at 100 meters is about 5×10^{-6}, five times higher than that assumed in NUREG-1140.

95. In the key point is that such "magic numbers" extrapolated--apparently incorrectly so--- from a tongue-in-cheek article in Health Physics is no substitute for a rigorous dispersion analysis using traditional dispersion models. We have done such an analysis, and varied the results by input assumption so that one can see the sensitivity of the result to the input presumed.

96. This is the kind of analysis the University should have performed in its application, and the kind of independent evaluation the NRC staff should have performed before deciding whether to grant the requested license amendment. A thorough assessment of the full literature on release fractions should have been performed, not just a blind repetition of inaccurate claims made by Rockwell about a couple of sources. An accurate recognition of the curie count and isotopic content of the plutonium source, and a sober recognition of the magnitude of the risk associated with that large an americium source, should have been undertaken. An understanding of the huge qualitative difference in dealing with these materials in unsealed form was essential. A full dispersion analysis, using the appropriate dispersion model (Reg. Guide 1.145) should have been performed by the University, varying the inputs about maximum inventory involved and true worst-case release fraction.

97. An accurate description of the fire loading in the alpha lab should have been done--not sliding over the fact that it is essentially built of 2 x 4s, a small wood house. A sober recognition that a basement fire involving radioactive materials would be very difficult to fight and that serious prefire planning and a thoroughly-worked-out emergency plan was necessary.

98. We suspect that in private Dr. Langhorst, Dr. Storvick, Dr. Morris, and others may admit that they cut corners and rushed to get the application in and approved and the initial experiments completed. We suspect several of the University personnel recognize privately that it was inappropriate to try to get the licenses approved secretly so that the public couldn't request a prior hearing. We suspect that some privately now recognize that they didn't fully appreciate the magnitude of the toxicity of the materials with which they were dealing or the fact that possessing them in those quantities put them in the top 18 of 21,000 materials licensees in terms of magnitude of potential harm to the public. We suspect that some are privately embarrassed at having to play calculational games with assumptions about stack releases and functioning HEPAs and miniscule release fractions in order to get estimated exposures down to supposedly acceptable levels.

99. In private some will probably now admit that they should have identified the full isotopic content of the plutonium and its true curie count; that the release fractions used from Schwendiman and Seehars in the "MURR Accident Summary" are among the lowest values one can find in the literature and unreasonable to use in a conservative safety analysis; that the assumption of a maximum 4-minute fire is a bit absurd; that they were intending all along to put in the HEPA filter after Mr. Steppen recommended it, and only decided to not stop the Np experiments while they waited for it to arrive, rather than, as now claimed, having doing a thorough analysis and deciding it was unnecessary.

100. But, with all that said, it remains true that something of great moment is at issue in Columbia. Not just whether an enterprise is permitted that could put at risk friends and loved ones in Columbia. But whether what the University is embarked upon will benefit humankind or lead to something of great destructiveness to international security and to the environment for generations to come.

101. At a time when Americans are worried that nations run by dictators abroad are working hard to be able to produce their own nuclear weapons materials, it is extraordinary that a mid-Western university could be engaged in a project that could make their job much easier. And at a time when the irreversible destruction of the environment has become more and more evident, it is extraordinary that university academics could be involved in a project hoping to dump 90% of high-level waste in dumpsites designed only for low-level wastes, risking pollution of ground water and soil on a scale never before conceived.

102. It would thus be a grave error, with potentially tragic outcomes, were this project to be given the green light without a full assessment of its potential impacts on the human environment.

COMMENTS ON THE AFFIDAVIT OF DANIEL J. OSETEK
"REGARDING SAFETY OF THE TRUMP-S PROJECT"

Page 6-7, on release fraction.--Mr. Osetek concludes that only the release fractions for burning plutonium metal or salt-contaminated combustibles are appropriate for consideration, and quotes the paper of Halverson et al. (PNL-5999, 1987). This conclusion is not fully correct in that no consideration was given to the possibility of a fire involving the molten salt phase (lithium chloride/potassium chloride), which contains plutonium chlorides. Chlorides are in general more volatile and more reactive than oxides, and thus might pose greater danger. Apparently, no experimental work has been done to permit one to estimate the release fractions.

Note that the "salt-contaminated combustibles" mentioned, as well for "salt release" mentioned on page 7, do not refer to the molten chlorides employed in the TRUMP-S experiments. Rather they refer to the use of uranyl nitrate (which is a type of salt) as a simulant for plutonium dioxide; the uranyl nitrate is mixed with combustibles. When pyrolyzed, uranyl nitrate decomposes to uranium oxide.

Mr. Osetek gave release fractions for burning plutonium in the range 2.8×10^{-8} to 5.3×10^{-4}. Indeed, some studies have shown results in this range for oxidation under ideal, quiescent circumstances. But there are a number of other studies which reveal that larger releases are sometimes encountered, depending on many variables (see JCW's critique). Expressed as percent, releases are sometimes as high as 0.05% for plutonium metal burning in a draft, and around 24% or higher for uranium dioxide in a gasoline fire. The results are variable, irreproducible, and erratic since the art of accident simulation in this field is at a primitive level. It is not really correct just to arbitrarily state, as Mr. Osetek does, that "the most conservative release fraction of 5.3×10^{-4} should be used."

In quoting the results of the paper by Halverson et al., Mr. Osetek states that the "largest release noted was 6.5×10^{-3} for polymethyl methacrylate," when the original paper says "releases ranged from about 0.25 to 4.5%" (corresponding to fractions of 0.0025 and 0.045). The "best estimate" for release fraction from metal or "salt" is given as 5.3×10^{-4}, but other experts could just as conscientiously arrive at a much higher figure. No one really knows what actual release fractions would be experienced in a fire. The discordant data available indicate that it would be of the order of 10^{-4} to 25 or 40%, depending strongly on circumstances such as presence or absence of combustibles, nature of combustibles, air velocity, and other factors.

James C. Warf
Dec. 9. 1990

Intervenors' Exhibit 20

Attachment A

Addendum to Critique on TRUMP-S

ACCIDENTS INVOLVING THE SALT PHASE

What would be the result of an accident in which the molten salt phase is exposed to air, or in which an explosion throws some of the melt into the air? There seems to be no literature on this topic, so only an inference can be made, based on a general knowledge of the chemistry of plutonium and other actinides. In this short discussion the fission products are not taken into account.

The molten LiCl/KCl phase contains some plutonium, almost certainly in the tripositive state. It might be $PuCl_3$ or a complex ion, such as $PuCl_5^{2-}$, both of which are expected to be greenish. These are reduced forms of plutonium, and if exposed to oxygen would be oxidized; moreover, atmospheric water vapor would cause hydrolysis. The final product would probably be PuO_2, although the oxo chloride $PuOCl_2$ is also a candidate. Corresponding oxo chlorides of thorium and neptunium are known. Hydrolysis alone could produce the plutonium(III) compound PuOCl; such compounds of lower actinides have been reported.

Two kinds of circumstances can be imagined: one in which air slowly leaks into a glove box containing the molten salt solution, and one in which an explosion disperses the liquid into air. In the first case, oxidation on the surface under more or less quiescent conditions would probably form a protective crust of oxide on the surface, which would retard further reaction. In the second case, in which the liquid salt is suddenly thrown into air, it is much more likely that oxo chlorides and oxides would be formed in a state of extreme subdivision, that is, as an easily airborne aerosol. Moreover, the fraction of such respirable is likely to be high.

Other notes to be incorporated into the text:

Plutonium dioxide is in general a nonstoichiometric compound, and this variable is one factor in its different colors.

When neptunium metal burns, it forms NpO_2 (greenish), Np_2O_5 (black), or Np_3O_8 (black), depending on the temperature and abundance of oxygen. Similarly, oxidation of americium forms either Am_2O_3 (pink) or AmO_2 (black). The airborne fractions are expected to resemble the case of plutonium.

REBUTTAL TO
"MEMORANDUM AND ORDER (Dissolution of Stay)"

This commentary refers to the Memorandum issued by Judge Peter B. Bloch regarding the TRUMP-S Project (LBP-90-41, November 16, 1990).

On page 8 of the referenced Memorandum, Judge Bloch states that "he is unable to accept the suggestion of the TRUMP-S panel that the release fraction should be treated as 3%," and "[t]hat suggestion is born of the Chernobyl experience, which resulted from a run-away reactor and a graphite fire."

This conclusion is erroneous to its core. The Intervenors mentioned the Chernobyl disaster only in a cursory manner, pointing out clearly that "there is a vast difference between the Chernobyl disaster and laboratory work with a few grams of actinide metals. The intent of the of making the comparison was only to demonstrate the qualitative similarity."

In fact, the basis of the estimated percentage of plutonium released into the atmosphere was not "born of the Chernobyl experience." It was born of the numerous studies of release fractions made by a variety of competent and respected experimenters in tests which spanned a spectrum of realistic circumstances. These tests were not all conducted under ideal quiescent conditions, which lead to minute release fractions, but in settings mimicking those expected to be encountered in real life. Most of the literature was summarized in the Intervenors' "A Critique of the TRUMP-S Process," (October 1990).

In the report mentioned, data were presented which showed that when combustible material is present, release fractions of plutonium or its simulants are greatly enhanced, ranging up to 11%, 24%, 40%, or even 55%. An estimate of 3 or 4% seems conservative. No one can predict in advance what the results in an actual accident might be.

The fraction of plutonium dioxide released via aerosolization which is respirable is also variable. In some circumstances it can be high. For example, Stewart showed that plutonium, oxidized at 120°C, "could cause a serious release of plutonium dioxide particulate of which a major fraction would be in the respirable range" (Critique, ref. 3). Similarly, Mishima and Schwendiman (Critique, ref. 15) demonstrated that in 8 of 11 experiments, more than 80% of the airborne particles were of respirable size.

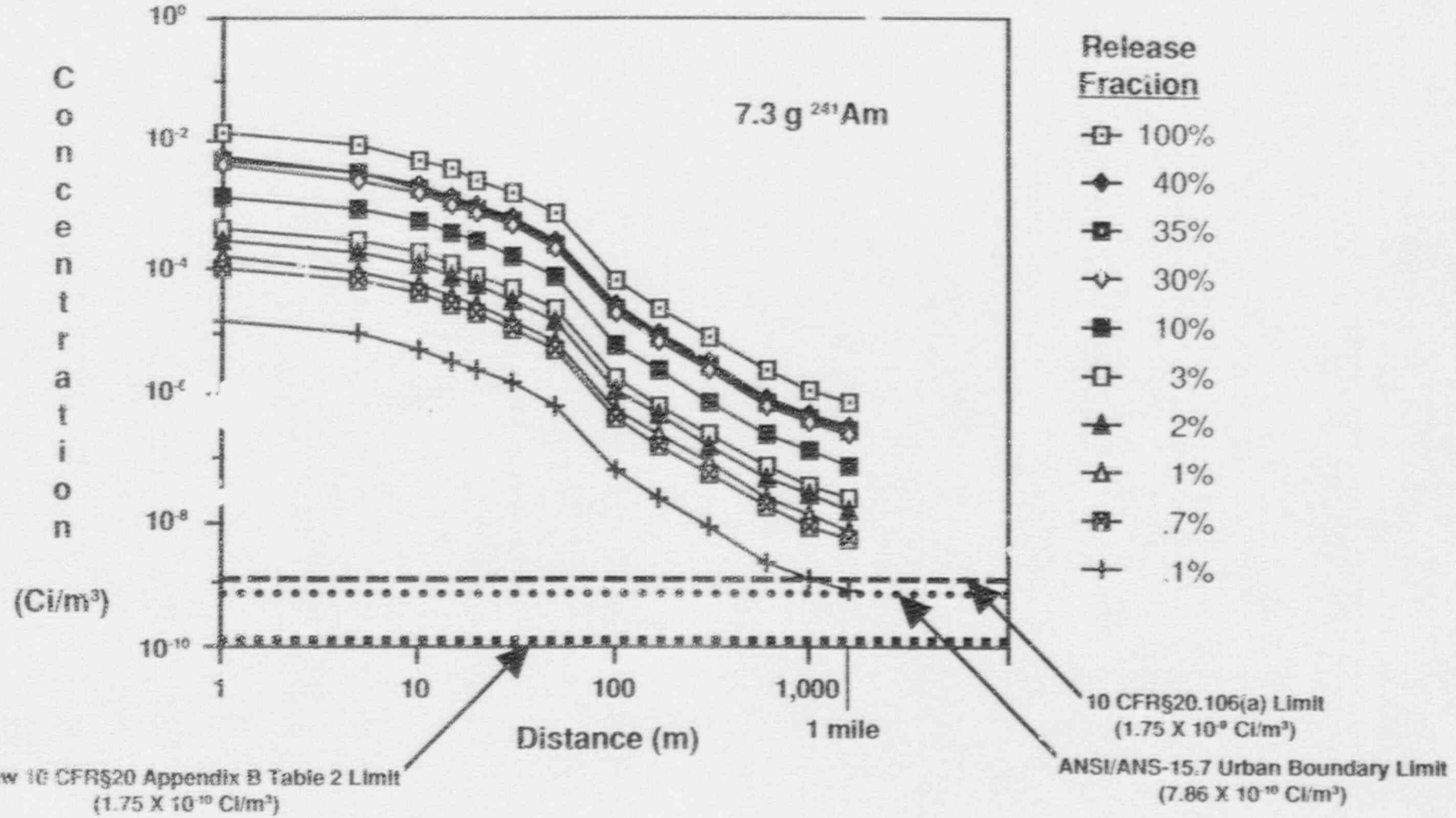
Judge Block states that "Indeed, based on what I now know, the use of Chernobyl for comparison seems highly inappropriate here" and he is certainly correct. What he should consider is that the Chernobyl debacle was not used significantly for com-

parison, but rather numerous actual experiments furnished the data for the Intervenors' judgments. To base an important decision on such a selective and incorrect premise seems to be misleading to say the least.

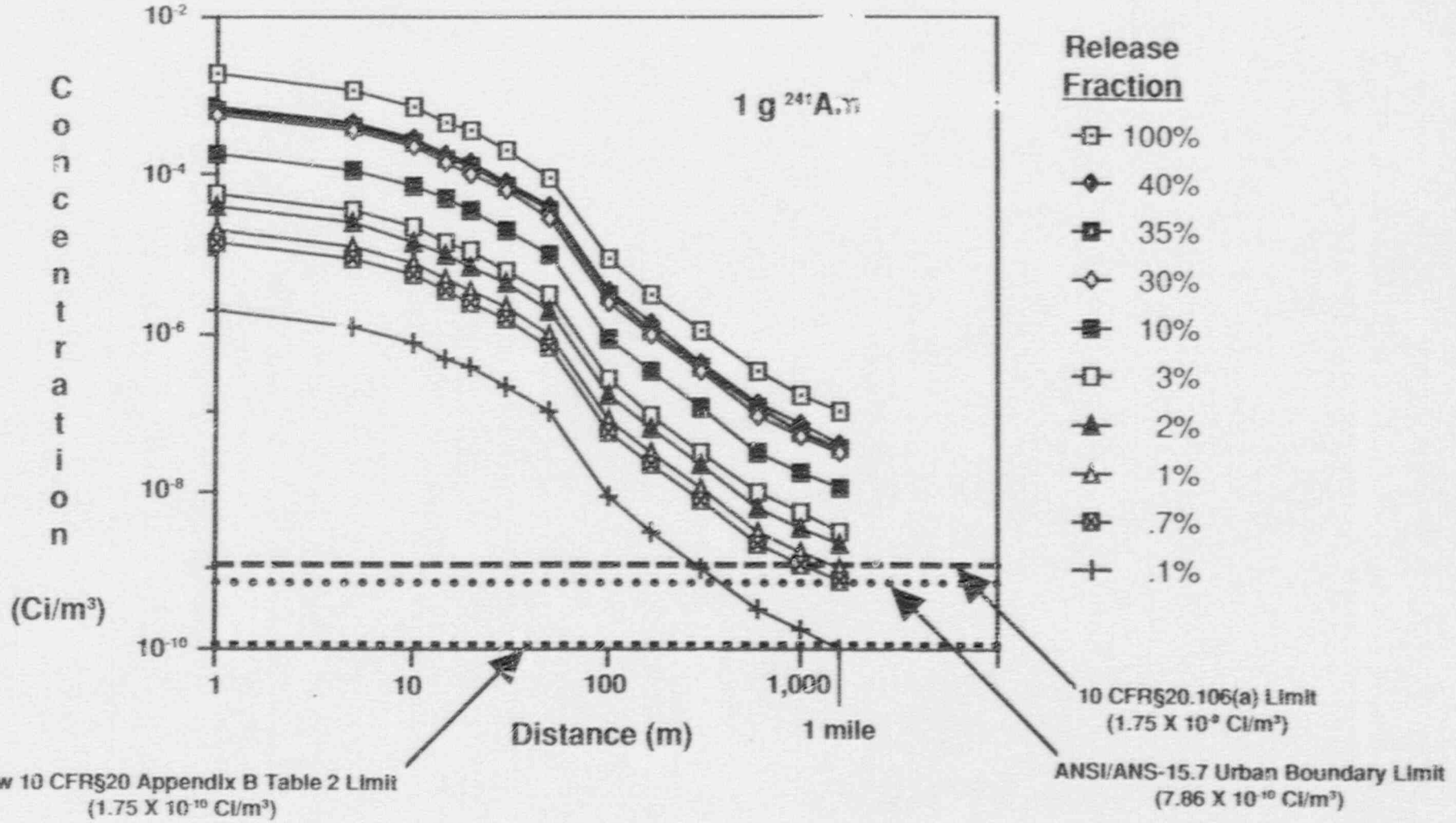
James C. Warf
December 5, 1990

Figure 1

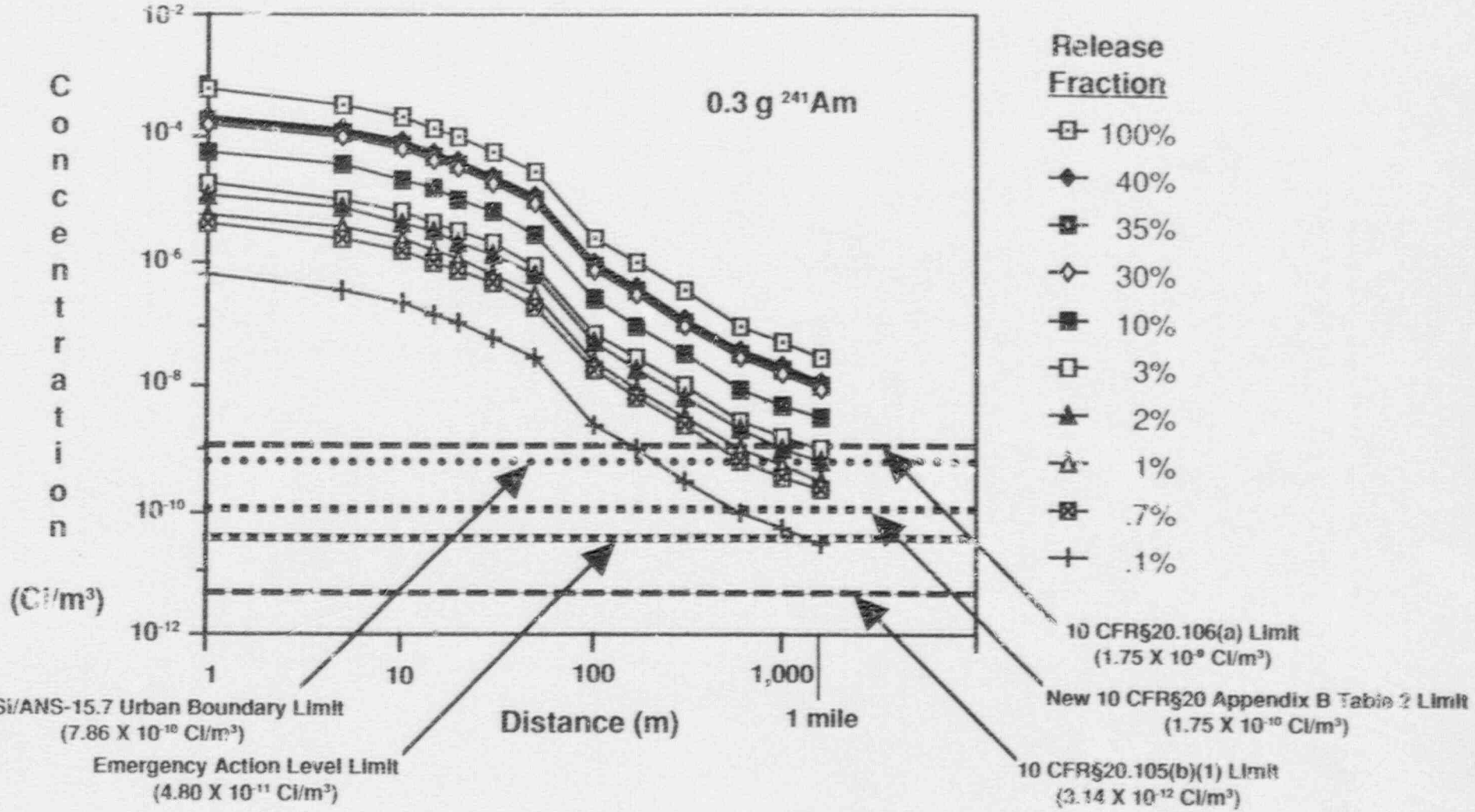
Concentration of Curies Per Cubic-Meter of Air at Various Distances Given 7.3 Grams (25 Ci) of Americium-241



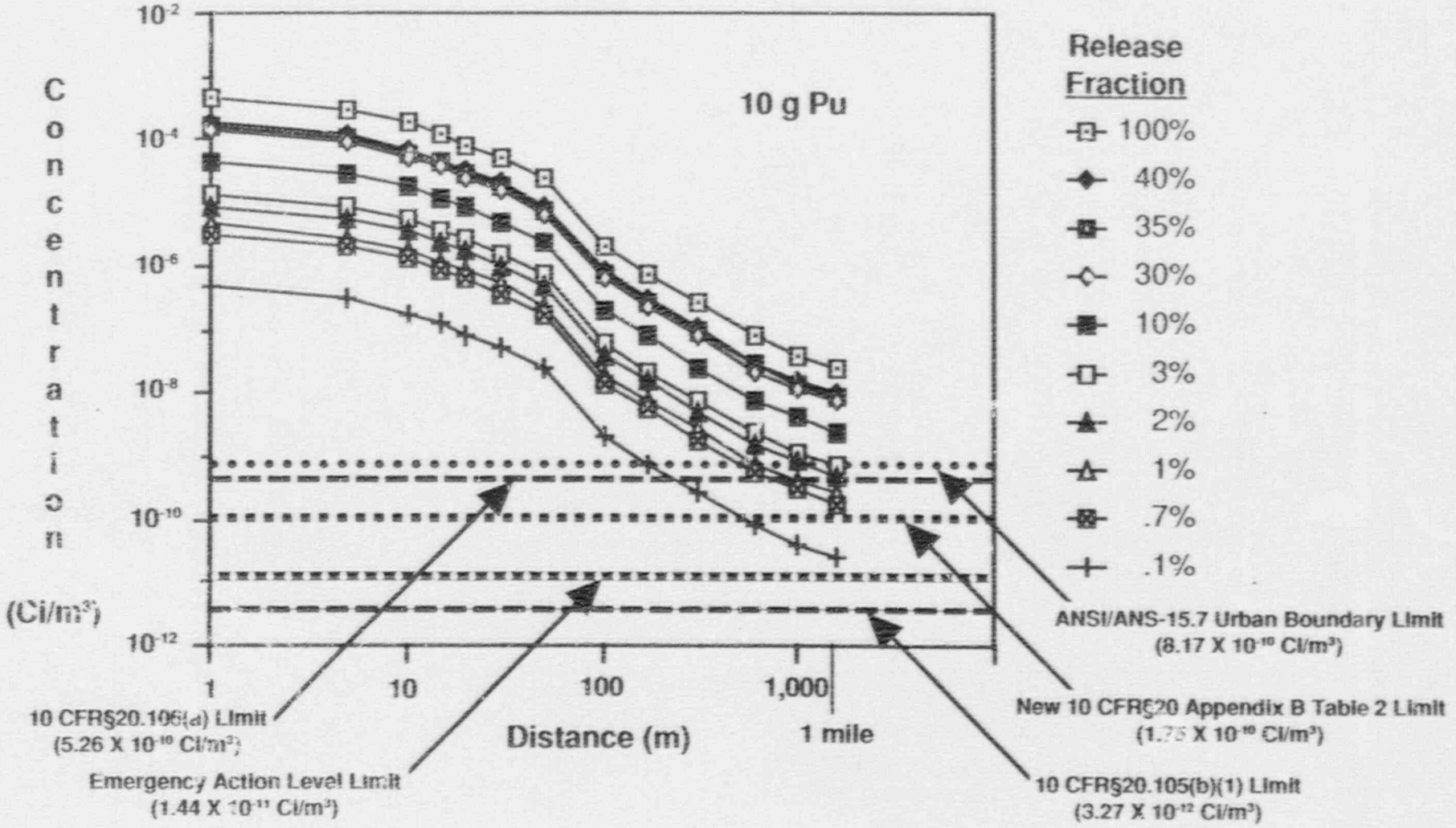
Concentration of Curies Per Cubic-Meter of Air at Various Distances Given 1 Gram (3.42 Ci) of Americium-241



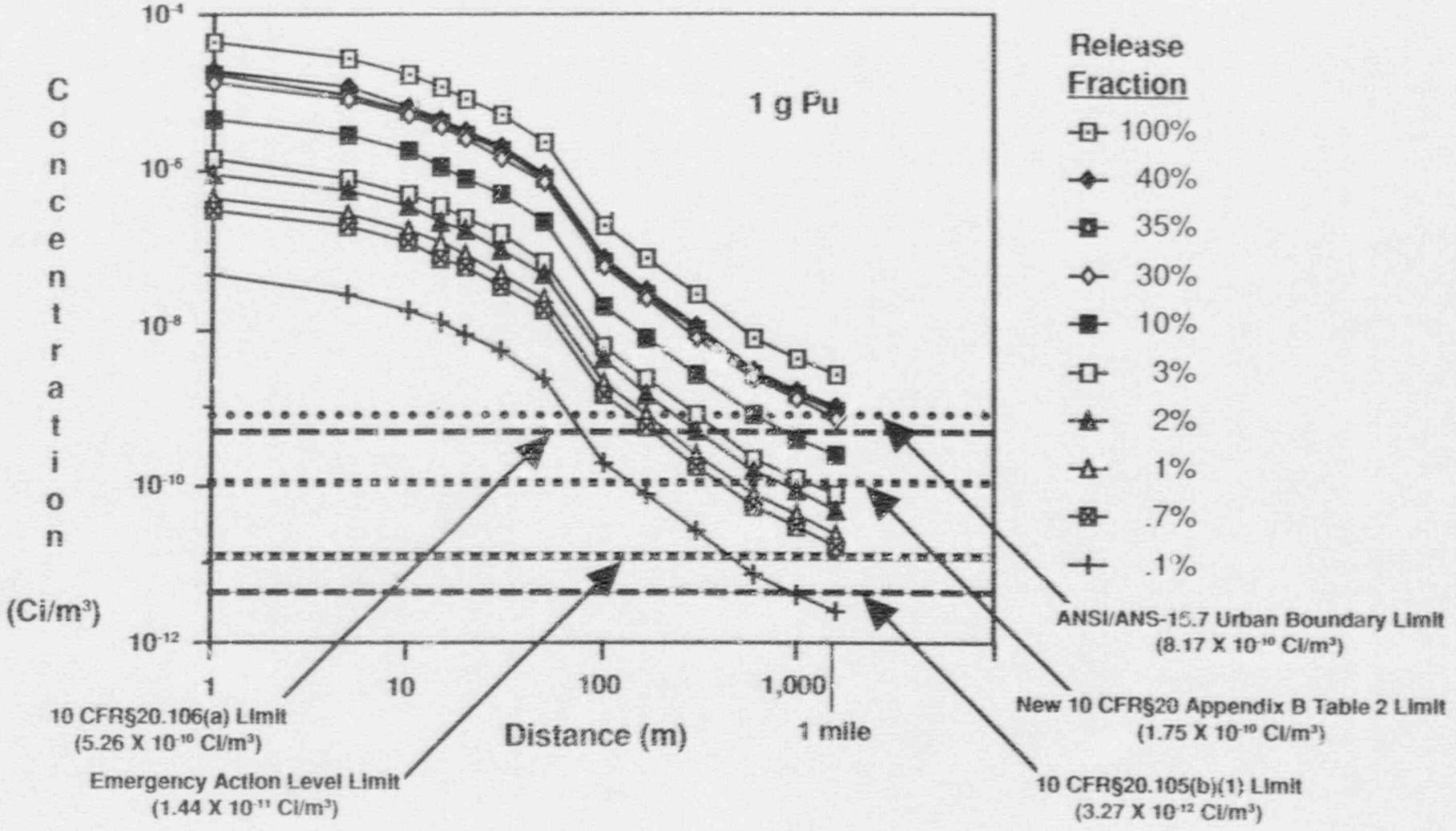
Concentration of Curies Per Cubic-Meter of Air at Various Distances Given 0.3 Grams (1.03 Ci) of Americium-241



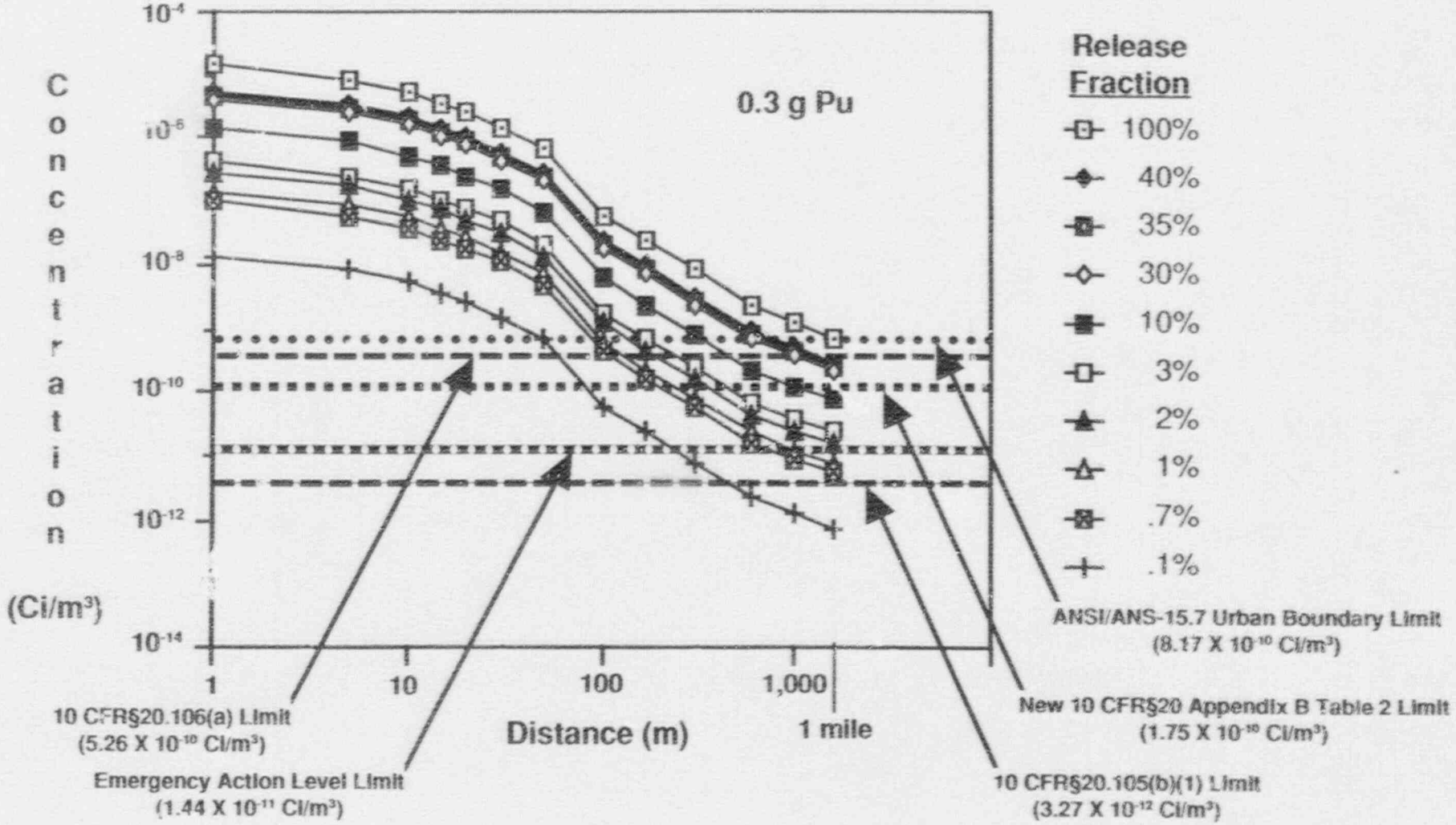
Concentration of Curies Per Cubic-Meter of Air at Various Distances Given 10 Grams (0.82 Ci) of Plutonium



Concentration of Curies Per Cubic-Meter of Air at Various Distances Given 1 Gram (0.082 Ci) of Plutonium



Concentration of Curies Per Cubic-Meter of Air at Various Distances Given 0.3 Grams (0.0246 Ci) of Plutonium



7.3g Am Wed, Dec 19, 1990 6:37 PM

	Distance (m)	100% RF	40% RF	35% RF	30% RF	10% RF
1	1	1.42E-02	5.67E-03	4.96E-03	4.25E-03	1.42E-03
2	5	8.75E-03	3.50E-03	3.06E-03	2.63E-03	8.75E-04
3	10	5.42E-03	2.17E-03	1.90E-03	1.63E-03	5.42E-04
4	15	3.58E-03	1.43E-03	1.25E-03	1.08E-03	3.58E-04
5	20	2.58E-03	1.03E-03	9.04E-04	7.75E-04	2.58E-04
6	30	1.54E-03	6.17E-04	5.40E-04	4.63E-04	1.54E-04
7	50	7.08E-04	2.83E-04	2.48E-04	2.13E-04	7.08E-05
8	100	6.04E-05	2.42E-05	2.11E-05	1.81E-05	6.04E-06
9	170	2.32E-05	9.29E-06	8.13E-06	6.97E-06	2.32E-06
10	300	7.95E-06	3.18E-06	2.78E-06	2.39E-06	7.95E-07
11	600	2.32E-06	9.29E-07	8.13E-07	6.97E-07	2.32E-07
12	1000	1.24E-06	4.97E-07	4.35E-07	3.73E-07	1.24E-07
13	1600	7.50E-07	3.00E-07	2.63E-07	2.25E-07	7.50E-08

Concentration given in Ci/m^3

Table 1

	3% RF	2% RF	1% RF	.7% RF	.1% RF
1	4.25E-04	2.83E-04	1.42E-04	9.92E-05	1.42E-05
2	2.63E-04	1.75E-04	8.75E-05	6.13E-05	8.75E-06
3	1.63E-04	1.08E-04	5.42E-05	3.79E-05	5.42E-06
4	1.08E-04	7.17E-05	3.58E-05	2.51E-05	3.58E-06
5	7.75E-05	5.17E-05	2.58E-05	1.81E-05	2.58E-06
6	4.63E-05	3.08E-05	1.54E-05	1.08E-05	1.54E-06
7	2.13E-05	1.42E-05	7.08E-06	4.96E-06	7.08E-07
8	1.81E-06	1.21E-06	6.04E-07	4.23E-07	6.04E-08
9	6.97E-07	4.64E-07	2.32E-07	1.63E-07	2.32E-08
10	2.39E-07	1.59E-07	7.95E-08	5.57E-08	7.95E-09
11	6.97E-08	4.64E-08	2.32E-08	1.63E-08	2.32E-09
12	3.73E-08	2.48E-08	1.24E-08	8.70E-09	1.24E-09
13	2.25E-08	1.50E-08	7.50E-09	5.25E-09	7.50E-10

	Distance (m)	100% RF	40% RF	35% RF	30% RF	10% RF
1	1	1.94E-03	7.76E-04	6.79E-04	5.82E-04	1.94E-04
2	5	1.20E-03	4.79E-04	4.20E-04	3.60E-04	1.20E-04
3	10	7.42E-04	2.97E-04	2.60E-04	2.23E-04	7.42E-05
4	15	4.91E-04	1.96E-04	1.72E-04	1.47E-04	4.91E-05
5	20	3.54E-04	1.42E-04	1.24E-04	1.06E-04	3.54E-05
6	30	2.11E-04	8.45E-05	7.39E-05	6.34E-05	2.11E-05
7	50	9.70E-05	3.88E-05	3.40E-05	2.91E-05	9.70E-06
8	100	8.27E-06	3.31E-06	2.90E-06	2.48E-06	8.27E-07
9	170	3.18E-06	1.27E-06	1.11E-06	9.54E-07	3.18E-07
10	300	1.09E-06	4.36E-07	3.81E-07	3.27E-07	1.09E-07
11	600	3.18E-07	1.27E-07	1.11E-07	9.54E-08	3.18E-08
12	1000	1.70E-07	6.81E-08	5.96E-08	5.11E-08	1.70E-08
13	1600	1.03E-07	4.11E-08	3.60E-08	3.08E-08	1.03E-08

Table 2

1g Am

Wed, Dec 19, 1990 11:34 PM

	3% RF	2% RF	1% RF	.7% RF	.1% RF
1	5.82E-05	3.88E-05	1.94E-05	1.36E-05	1.94E-06
2	3.60E-05	2.40E-05	1.20E-05	8.39E-06	1.20E-06
3	2.23E-05	1.48E-05	7.42E-06	5.19E-06	7.42E-07
4	1.47E-05	9.82E-06	4.91E-06	3.44E-06	4.91E-07
5	1.06E-05	7.08E-06	3.54E-06	2.48E-06	3.54E-07
6	6.34E-06	4.22E-06	2.11E-06	1.48E-06	2.11E-07
7	2.91E-06	1.94E-06	9.70E-07	6.79E-07	9.70E-08
8	2.48E-07	1.65E-07	8.27E-08	5.79E-08	8.27E-09
9	9.54E-08	6.36E-08	3.18E-08	2.23E-08	3.18E-09
10	3.27E-08	2.18E-08	1.09E-08	7.63E-09	1.09E-09
11	9.54E-09	6.36E-09	3.18E-09	2.23E-09	3.18E-10
12	5.11E-09	3.40E-09	1.70E-09	1.19E-09	1.70E-10
13	3.08E-09	2.05E-09	1.03E-09	7.19E-10	1.03E-10

	Distance (m)	100% RF	40%	35%	30%	10%
1	1	5.82E-04	2.33E-04	2.04E-04	1.75E-04	5.82E-05
2	5	3.60E-04	1.44E-04	1.26E-04	1.08E-04	3.60E-05
3	10	2.23E-04	8.90E-05	7.79E-05	6.68E-05	2.23E-05
4	15	1.47E-04	5.89E-05	5.15E-05	4.42E-05	1.47E-05
5	20	1.06E-04	4.25E-05	3.72E-05	3.18E-05	1.06E-05
6	30	6.34E-05	2.53E-05	2.22E-05	1.90E-05	6.34E-06
7	50	2.91E-05	1.16E-05	1.02E-05	8.73E-06	2.91E-06
8	100	2.48E-06	9.93E-07	8.69E-07	7.44E-07	2.48E-07
9	170	9.54E-07	3.82E-07	3.34E-07	2.86E-07	9.54E-08
10	300	3.27E-07	1.31E-07	1.14E-07	9.81E-08	3.27E-08
11	600	9.54E-08	3.82E-08	3.34E-08	2.86E-08	9.54E-09
12	1000	5.11E-08	2.04E-08	1.79E-08	1.53E-08	5.11E-09
13	1600	3.08E-08	1.23E-08	1.08E-08	9.25E-09	3.08E-09

Table 3

	3%	2%	1%	.7%	.1%
1	1.75E-05	1.16E-05	5.82E-06	4.08E-06	5.82E-07
2	1.08E-05	7.19E-06	3.60E-06	2.52E-06	3.60E-07
3	6.68E-06	4.45E-06	2.23E-06	1.56E-06	2.23E-07
4	4.42E-06	2.95E-06	1.47E-06	1.03E-06	1.47E-07
5	3.18E-06	2.12E-06	1.06E-06	7.43E-07	1.06E-07
6	1.90E-06	1.27E-06	6.34E-07	4.43E-07	6.34E-08
7	8.73E-07	5.82E-07	2.91E-07	2.04E-07	2.91E-08
8	7.44E-08	4.96E-08	2.48E-08	1.74E-08	2.48E-09
9	2.86E-08	1.91E-08	9.54E-09	6.68E-09	9.54E-10
10	9.81E-09	6.54E-09	3.27E-09	2.29E-09	3.27E-10
11	2.86E-09	1.91E-09	9.54E-10	6.68E-10	9.54E-11
12	1.53E-09	1.02E-09	5.11E-10	3.57E-10	5.11E-11
13	9.25E-10	6.16E-10	3.08E-10	2.16E-10	3.08E-11

10g Pu

Thu, Dec 20, 1990 4:52 PM

	Distance (m)	100% RF	40% RF	35% RF	30% RF	10% RF
1	1	4.65E-04	1.86E-04	1.63E-04	1.39E-04	4.65E-05
2	5	2.87E-04	1.15E-04	1.00E-04	8.61E-05	2.87E-05
3	10	1.78E-04	7.11E-05	6.22E-05	5.33E-05	1.78E-05
4	15	1.18E-04	4.70E-05	4.11E-05	3.53E-05	1.18E-05
5	20	8.47E-05	3.39E-05	2.97E-05	2.54E-05	8.47E-06
6	30	5.06E-05	2.02E-05	1.77E-05	1.52E-05	5.06E-06
7	50	2.32E-05	9.29E-06	8.13E-06	6.97E-06	2.32E-06
8	100	1.98E-06	7.92E-07	6.93E-07	5.94E-07	1.98E-07
9	170	7.62E-07	3.05E-07	2.67E-07	2.29E-07	7.62E-08
10	300	2.61E-07	1.04E-07	9.13E-08	7.83E-08	2.61E-08
11	600	7.62E-08	3.05E-08	2.67E-08	2.29E-08	7.62E-09
12	1000	4.08E-08	1.63E-08	1.43E-08	1.22E-08	4.08E-09
13	1600	2.46E-08	9.84E-09	8.61E-09	7.38E-09	2.46E-09

Table 4

	3% RF	2% RF	1% RF	.7% RF	.1% RF
1	1.39E-05	9.29E-06	4.65E-06	3.25E-06	4.65E-07
2	8.61E-06	5.74E-06	2.87E-06	2.01E-06	2.87E-07
3	5.33E-06	3.55E-06	1.78E-06	1.24E-06	1.78E-07
4	3.53E-06	2.35E-06	1.18E-06	8.23E-07	1.18E-07
5	2.54E-06	1.69E-06	8.47E-07	5.93E-07	8.47E-08
6	1.52E-06	1.01E-06	5.06E-07	3.54E-07	5.06E-08
7	6.97E-07	4.65E-07	2.32E-07	1.63E-07	2.32E-08
8	5.94E-08	3.96E-08	1.98E-08	1.39E-08	1.98E-09
9	2.29E-08	1.52E-08	7.62E-09	5.33E-09	7.62E-10
10	7.83E-09	5.22E-09	2.61E-09	1.83E-09	2.61E-10
11	2.29E-09	1.52E-09	7.62E-10	5.33E-10	7.62E-11
12	1.22E-09	8.15E-10	4.08E-10	2.85E-10	4.08E-11
13	7.38E-10	4.92E-10	2.46E-10	1.72E-10	2.46E-11

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	Distance (m)	100% RF	40% RF	35% RF	30% RF	10% RF
1	1	4.65E-05	1.86E-05	1.63E-05	1.39E-05	4.65E-06
2	5	2.87E-05	1.15E-05	1.00E-05	8.61E-06	2.87E-06
3	10	1.78E-05	7.11E-06	6.22E-06	5.33E-06	1.78E-06
4	15	1.18E-05	4.70E-06	4.11E-06	3.53E-06	1.18E-06
5	20	8.47E-06	3.39E-06	2.97E-06	2.54E-06	8.47E-07
6	30	5.06E-06	2.02E-06	1.77E-06	1.52E-06	5.06E-07
7	50	2.32E-06	9.29E-07	8.13E-07	6.97E-07	2.32E-07
8	100	1.98E-07	7.92E-08	6.93E-08	5.94E-08	1.98E-08
9	170	7.62E-08	3.05E-08	2.67E-08	2.29E-08	7.62E-09
10	300	2.61E-08	1.04E-08	9.13E-09	7.83E-09	2.61E-09
11	600	7.62E-09	3.05E-09	2.67E-09	2.29E-09	7.62E-10
12	1000	4.08E-09	1.63E-09	1.43E-09	1.22E-09	4.08E-10
13	1600	2.46E-09	9.84E-10	8.61E-10	7.38E-10	2.46E-10

Table 5

	3% RF	2% RF	1% RF	.7% RF	.1% RF
1	1.39E-06	9.29E-07	4.65E-07	3.25E-07	4.65E-08
2	8.61E-07	5.74E-07	2.87E-07	2.01E-07	2.87E-08
3	5.33E-07	3.55E-07	1.78E-07	1.24E-07	1.78E-08
4	3.53E-07	2.35E-07	1.18E-07	8.23E-08	1.18E-08
5	2.54E-07	1.69E-07	8.47E-08	5.93E-08	8.47E-09
6	1.52E-07	1.01E-07	5.06E-08	3.54E-08	5.06E-09
7	6.97E-08	4.65E-08	2.32E-08	1.63E-08	2.32E-09
8	5.94E-09	3.96E-09	1.98E-09	1.39E-09	1.98E-10
9	2.29E-09	1.52E-09	7.62E-10	5.33E-10	7.62E-11
10	7.83E-10	5.22E-10	2.61E-10	1.83E-10	2.61E-11
11	2.29E-10	1.52E-10	7.62E-11	5.33E-11	7.62E-12
12	1.22E-10	8.15E-11	4.08E-11	2.85E-11	4.08E-12
13	7.38E-11	4.92E-11	2.46E-11	1.72E-11	2.46E-12

	Distance (m)	100% RF	40% RF	35% RF	30% RF	10% RF
1	1	1.39E-05	5.58E-06	4.88E-06	4.18E-06	1.39E-06
2	5	8.61E-06	3.44E-06	3.01E-06	2.58E-06	8.61E-07
3	10	5.33E-06	2.13E-06	1.87E-06	1.60E-06	5.33E-07
4	15	3.53E-06	1.41E-06	1.23E-06	1.06E-06	3.53E-07
5	20	2.54E-06	1.02E-06	8.90E-07	7.63E-07	2.54E-07
6	30	1.52E-06	6.07E-07	5.31E-07	4.55E-07	1.52E-07
7	50	6.97E-07	2.79E-07	2.44E-07	2.09E-07	6.97E-08
8	100	5.94E-08	2.38E-08	2.08E-08	1.78E-08	5.94E-09
9	170	2.29E-08	9.14E-09	8.00E-09	6.86E-09	2.29E-09
10	300	7.83E-09	3.13E-09	2.74E-09	2.35E-09	7.83E-10
11	600	2.29E-09	9E-10	8.00E-10	6.86E-10	2.29E-10
12	1000	1.22E-09	49E-10	4.28E-10	3.67E-10	1.22E-10
13	1600	7.38E-10	2.95E-10	2.58E-10	2.21E-10	7.38E-11

Table 6

	3% RF	2% RF	1% RF	.7% RF	.1% RF
1	4.18E-07	2.79E-07	1.39E-07	9.76E-08	1.39E-08
2	2.58E-07	1.72E-07	8.61E-08	6.03E-08	8.61E-09
3	1.60E-07	1.07E-07	5.33E-08	3.73E-08	5.33E-09
4	1.06E-07	7.05E-08	3.53E-08	2.47E-08	3.53E-09
5	7.63E-08	5.08E-08	2.54E-08	1.78E-08	2.54E-09
6	4.55E-08	3.03E-08	1.52E-08	1.06E-08	1.52E-09
7	2.09E-08	1.39E-08	6.97E-09	4.88E-09	6.97E-10
8	1.78E-09	1.19E-09	5.94E-10	4.16E-10	5.94E-11
9	6.86E-10	4.57E-10	2.29E-10	1.60E-10	2.29E-11
10	2.35E-10	1.57E-10	7.83E-11	5.48E-11	7.83E-12
11	6.86E-11	4.57E-11	2.29E-11	1.60E-11	2.29E-12
12	3.67E-11	2.45E-11	1.22E-11	8.56E-12	1.22E-12
13	2.21E-11	1.48E-11	7.38E-12	5.17E-12	7.38E-13

CURRICULUM VITAE

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EDUCATION:

B. S. - Physics - 1961
City College of New York
New York, New York

M. S. in Radiation Physics - 1963
College of Physicians and Surgeons
Columbia University
New York, New York

CERTIFICATION:

American Board of Radiology -
Therapy Physics - June, 1981

TEACHING

1987 - present Lecturer -
Radiation Oncology-Physics
University of California, Los
Angeles Los Angeles, California

PROFESSIONAL SOCIETIES:

American Association of Physicists in Medicine
President, Southern California Chapter of the AAPM-1974-1975

Health Physics Society

American Society of Therapeutic Radiologists

American College of Radiology

California Chapter American College of Radiology

EXPERIENCE

September 1972 to present - Southern Califorina Permanente Medical Group Los Angeles, California

Duties include radiation therapy treatment planning using computers, maintaining and searching records of a computerized patient tumor registry, using computer programs to analyze results of patient treatment, area radiation safety officer, custodian of sealed sources. I have witten radiation safety surveys on the seven megavoltage and three orthovoltage radiation therapy machines in the department. I have performed the biannual calibration of these machines. I am teaching and training residents in radiation physics.

1966 to 1972 - Cedars of Lebanon Hospital Los Angeles, California

My duties included radiation therapy treatment planning and custodian of the sealed, radioactive sources. I was responsible for the introduction and opertion of the time sharing computer for radiation therapy treatment planning.

I had written several computer programs and had bean instrumental in establishing computer operations in other hospitals in the area. Teaching of radiology residents and x-ray technicians were also included in my activities. As radiation safety officer, I was responsible for the radiation safety program in the hospital.

1965 to 1966 - University Hospital Ann Arbor, Michigan

Duties included radiation therapy treatment planning. I assisted in teaching and training radiology residents. I aided in maintaining and insuring the proper operation of the radiation therapy equipment.

1964 to 1965

Sloan-Kettering Institute
New York, New York

As a Research Assistant I investigated the use of solid state devices as radiation detectors.

1961 to 1963

Western Electric Company
Kearney, New Jersey

As an Equipment Engineer I helped arrange new telephone switching equipment in central offices.

BIOGRAPHY

Joseph K. Lyou, Ph.D.

My name is Dr. Joseph K. Lyou. I am currently Associate Director of the Committee to Bridge the Gap, a Los Angeles-based research organization focusing on nuclear matters. My duties include research, statistical calculations and presentation, and evaluation of technical data on a variety of nuclear questions.

I have a doctorate in social psychology from the University of California, Santa Cruz, with considerable training in statistics. At UCSC I was closely associated with the Adlai Stevenson Program on Nuclear Policy, a research and teaching program at the university then directed by Daniel Hirsch, the current President of CBG. My doctoral dissertation was on nuclear matters. In addition to my current duties at CBG, I do consulting in statistics.

I declare under penalty of perjury that the foregoing is true and correct.

James C. Warf

James C. Warf, Ph.D.

Executed at Los Angeles, California
this 24th day of December, 1990

I declare under penalty of perjury that the foregoing is true and correct.

Sheldon C. Plotkin

Sheldon C. Plotkin, Ph.D.

Executed at Los Angeles, California
this 24th day of December, 1990

I declare under penalty of perjury that the foregoing is true and correct.

Lowell G. Wayne

Lowell Wayne, Ph.D.

Executed at Arcata, California
this 23rd day of December, 1990

I declare under penalty of perjury that the foregoing is true and correct.

Myron Wollin

Executed at Los Angeles, California
this 24 day of December, 1990

I declare under penalty of perjury that the foregoing is true and correct.

Joseph K. Lyou, Ph.D.

Executed at Los Angeles, California
this 24th day of December, 1990

I declare under penalty of perjury that the foregoing is true and correct.

Daniel Hirsch

Executed at Los Angeles, California
this 24th day of December, 1990

I declare under penalty of perjury that the foregoing is true and correct.

Miguel Pulido

Executed at Santa Ana, California
this 24th day of December, 1990

CERTIFICATE OF SERVICE

True copies of the foregoing were mailed this 24th day of December 1990, by United States Express Mail, postage prepaid, to:

The Honorable Peter B. [illegible]ch
Administrative Law Judge
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, DC 20555

The Honorable Gustave A. Linenberger, Jr.
Administrative Law Judge
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U.S. Nuclear Regulatory Commission
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and by first class mail, postage prepaid, to:

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