GENERIC ENVIRONMENTAL STATEMENT MIXED OXIDE FUELS FOR RECYCLE PLUTONIUM IN LIGHT WATER COOLED REACTORS, COMMENTS BY THE ENVIRONMENTAL PROTECTION AGENCY.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

21 NOV 1974

Dr. S. H. Smiley
Deputy Director for Fuels
and Materials
Directorate of Licensing
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dear Dr. Smiley:

The Environmental Protection Agency has reviewed the draft Generic Environmental Statement Mixed Oxide Fuels for Recycle Plutonium in Light Water Cooled Reactors. Our detailed comments are enclosed.

We would like to thank you and your staff for the time spent in meeting with EPA staff members to discuss the issues raised during the review of GESMO. These meetings were helpful to EPA for the purposes of narrowing issues and hopefully prepared your staff for responding to our comments on GESMO. Recognizing the scope of the problems and the difficulty of addressing them at a level of detail not heretofore approached, we commend the AEC staff for earnestly attempting to present a fair picture of the plutonium recycle problem.

In its review, EPA has attempted to determine whether the information provided is complete and adequate to support the conclusions reached in the draft statement. The EPA comments do not, however, address the completeness or adequacy of the technical aspects of plutonium safeguards since this Agency does not have expertise for such a technical analysis and hopefully, such a detailed review will be made by those agencies of the U.S. Government having this expertise. Because of the extreme importance of adequate safeguards, our comments do reflect concern with the general and cost/benefit aspects of the safeguards program. The EPA review of the GESMO was also based on the premise that the program as proposed does not include the exportation of plutonium.

Until the information requested by EPA to be included in the final statement is available, no final judgment can be made on the environmental acceptability of this program. However, our preliminary findings are that the implementation of plutonium recycle on an industry-wide basis appears to be marginally acceptable from a cost/benefit balance. This analysis indicates that the timeliness of the program implementation does not appear to be critical. With the application of the revised cost/benefit analysis methodology that we recommend, the timeliness may be even less critical and the cost/benefit balance even more marginal. It also appears that the program could result in some environmental advantages. Within this perspective, the principal conclusions reached by EPA on the plutonium recycle program are as follows:

1. Before a full scale mixed oxide recycle program is implemented a commitment should be made to an acceptable safeguards program. Such commitment should include the completion of the necessary selection of a procedure, its development and the securing of regulatory or legislative approvals for its implementation, including funding mechanisms.

2. Before actual full-scale mixed oxide fabrication and fueling of light water reactors is commenced, the following should be accomplished:

(a) the safeguards program should be implemented;

(b) the waste disposal concerns about transuranic wastes identified in EPA's review of the draft statement, "Management of Commercial High-Level and Transuranium -- Contaminated Radioactive Waste," and the proposed rulemaking on transuranic waste should be resolved; and

(c) accident analysis of specific plutonium recycle reactor designs should be completed for each proposed application and deemed satisfactory.

Relative to the adequacy of the draft GESMO, EPA has commented on several subject areas. First, the methodology used to compare the costs of using recycled plutonium to the base case. Second, the role of population exposures from uranium processing and occupational exposures in the reported reduction of dose from use of mixed oxide fuels. Third, our review includes comments on the uncertainties of plutonium toxicity and pathways of radionuclides to man.

EPA is very much aware of the controversy that exists relative to transuranium uncertainties. We are attempting to resolve these through a program of information development and consideration of the need to establish generally applicable environmental standards for the transuranium elements. EPA has stated this intent and requested relevant information in a Federal Register Notice, Vol. 39, No. 185 - Monday, September 23, 1974. We are confident that any standards promulgated through this process will be implemented by the Commission. We feel that these parallel efforts of the EPA and the AEC will adequately protect the public health and safety and the environment.

Based on our reservations about safeguards and in accordance with EPA procedure, we have classified the project as ER (Environmental Reservations) and rated the draft statement as Category 2 (Insufficient Information). If you or your staff have any questions concerning our classification or comments, please do not hesitate to call on us.

Sincerely yours,

Sheldon Meyers

Sheldon Meyers
Director
Office of Federal Activities (A-104)

Enclosure

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I. INTRODUCTION AND CONCLUSIONS

The Environmental Protection Agency (EPA) has completed its review of the Generic Environmental Statement Mixed Oxide Fuel (GESMO) on Recycle Plutonium in Light Water Cooled Reactors issued on August 23, 1974. The conclusion stated by AEC based on their analysis is that the recycle of plutonium in light water reactors should be approved subject to continuation of detailed case-by-case licensing procedures and upgraded safeguards. Both environmental and economic factors were analyzed in GESMO by AEC.

In its review, EPA has attempted to determine whether the information provided is complete and adequate to support the conclusions reached in the draft statement. The EPA comments do not, however, address the completeness or adequacy of the technical aspects of plutonium safeguards since this Agency does not have expertise for such a technical analysis. We would expect that such a detailed review will be made by those agencies of the U.S. Government having this expertise. Because of the great importance of adequate safeguards, our comments do reflect concern with the general and cost/benefit aspects of the safeguards program. The EPA review of the GESMO was also based on the premise that the program as proposed does not include the exportation of plutonium. A decision to export plutonium and the related safeguards considerations should be a separate issue.

EPA has included comments on the cost/benefit analysis since it considers factors which are environmental and public health related, and since it is relevant to potential risks assumed. EPA reviewed the analysis from the standpoint of methodology, data utilized and the degree to which it presents an independent evaluation of program costs and benefits. Additionally, there have been cases within the nuclear industry where abandonment of economically marginal operations have left State and Federal governments with a legacy of environmental radiation problems. Example of these operations include abandoned uranium mill tailings and low-level waste storage sites. In order to assess the probability of similar occurrences in the future, EPA must evaluate the economic viability of proposed projects which could result in undesirable environmental legacies.

The implementation of plutonium recycle on an industry-wide basis appears at best to be marginally acceptable from a cost/ benefit balance. The AEC analysis indicates that the timeliness of the program implementation does not appear to be critical. With the application of the revised cost/benefit analysis methodology that we recommend, the timeliness may be even less critical and the cost/benefit balance even more marginal. It also appears that the program could result in some environmental advantages. Within this perspective, the principal conclusions reached by EPA on the GESMO program are as follows:

1. Before a mixed oxide recycle program is initiated, a commitment should be made to an acceptable safeguards program. Such a commitment should include the completion of the necessary selection of a procedure, its development, and the securing of regulatory or legislative approvals for its implementation including funding mechanisms.

2. Before actual full scale mixed oxide fabrication and fueling of light water reactors is commenced, the following should be accomplished:

(a) the safeguards program should be implemented or operational. (b) the waste disposal concerns about transuranium waste identified in EPA's current NEPA review of the draft statement, "Management of Commercial High-Level and Transuranium -- Contaminated Radioactive Waste," and the proposed rulemaking on transuranic waste should be resolved: and (c) accident analysis of specific plutonium recycle reactor designs should be completed for each proposed application and deemed satisfactory. These conclusions are not different in concept from AEC's approach, but rely on specific milestones as decision points as opposed to time intervals as specified by AEC.

Relative to the adequacy of the draft GESMO EIS, EPA makes the following additional comments:

1. The methodology used to compare the costs of using recycled plutonium to the base case of not recycling can be significantly improved. We recommend that a sensitivity analyses be performed to determine how sensitive the cost savings from recycling are to

changes in the growth of electrical energy demand, uranium availability, and changes in estimated capital costs of mixed oxide facilities and safeguards measures. The final statement should also expand the discussion of the economic timing of the commercialization of plutonium recycle. Application of improved cost/benefit methodology may indicate that the economic incentives for introduction of plutonium recycle may influence the time of introduction.

The cost benefit analysis should consider any inherent government subsidy of plutonium recycle. In particular, the safeguards proposals describe government actions which may involve direct or indirect government subsidies, such that a program that is marginally acceptable to society as a whole, might otherwise be unsually attractive to industry.

2. In the draft statement the increased population exposures from mixed oxide fuel processing are said to be offset by reduced exposures from mining and milling of uranium ore. It is not made clear the extent to which plutonium is or is not the dominant environmental consideration. The application of "As Low As Practicable" concepts to uranium processing are not included in the statement.

3. Occuptional exposures are not discussed in detail. Although these deficiencies may not be crucial for final conclusions regarding acceptability of plutonium recycle, it is possible the dose savings may not exceed the increased exposures from the rest of the mixed oxide cycle.

4. The values of radiation dose equivalents and population dose reported in GESMO were calculated using assumptions and a data base that were not included in the statement. To evaluate the adequacy of the transport of radionuclides in the environment, the assumptions and pathways used in these calculations should be included in the final statement.

II. PLUTONIUM CONSIDERATIONS

a. Radiation dose and Plutonium Toxicity

Basically two comparisions relative to radiation dose and health effects can be made between the MOX cycle and the base LWR case. One is for occupational exposure and the other for the general population. Neither of these discernments are clearly delineated.

In the case of occupational exposures it would be helpful to identify the types of workers at risk and the sources of information on their exposure. It is not clear in the EIS whether uranium miners were included and if so if their occupational hazards not due to radiation were considered as part of the health impact.

In the EIS, the increased occupational and population exposures from mixed oxide fuel processing are said to be offset by reduced exposures from mining and milling of uranium ore. Indeed an actual overall dose savings is indicated. However, it does not appear that the two cases were similarly treated. To the degree that the dose estimates for mining and milling were based on models which do not reflect the control technology forecast for the 1990's, and exposures from the mixed oxide cycle were evaluated on more realistic effluent releases (ALAP), it is possible that the dose savings shown in the EIS for reduced uranium processing may not balance so favorably the increased exposure from the rest of the MOX cycle. Therefore, the AEC should review the bases for the dose estimates from mining and milling to see if they are compatible with assumptions used to evaluate the dose from other sources of exposure.

Throughout the discussion on toxicity, dose and health effects, numerous points are in need of clarification or other resolution. These individual points are presented in the additional comments section. However, some issues so pervade the whole discussion that some remarks are appropriate at this point.

Primary among these is the manner of utilizing and extrapolating animal data to interpretation of effects on man. As precarious as this manner always is, the EIS seems to make it

even more so by implying a false sense of security in the stated conclusions. A prime example is the area of lung effects utilizing data from dogs and cats which have no common denominator for comparision with human lung effects. This general situation is compounded by a lack of information on experimental procedure, such as chemical form for experiments at high dose rates as a basis to infer effects on man at low dose rates.

Some other issues include the need to examine the potential effects of other transplutonium radionuclides in order to place them in perspective and premature biological conclusions such as assuming the gonads to not be a potential internal organ. These areas of ambiguity present a case which may well be misleading and this matter should be resolved in the final EIS. We feel that our detailed comments previously referred to along with the references we have presented should be of assistance in carrying this out. Although the results will probably not change conclusions relative to the program's acceptability they will certainly more clearly state the related impact and the degree of uncentainty associated with it.

b. Radionuclide Pathways in the Environment

The primary area of concern relative to environmental pathways is the direct inhalation interface involved with the resuspension of plutonium from soils. Several specific comments relative to the discussion of this are included in the additional comments. In general however, it is felt that this is an area where much more effort is required although it is realized it may be sometime before it is entirely resolved. The present sparsity of data is compounded by the fact that much of it is from desert test areas and may not be at all applicable to the urban and suburban areas of most concern. The program to determine this parameter is all the more critical due to the sensitivity of lung doses to the resuspension variables. We hope that a vigorous effort will be pursued and to the extent possible the planned program be described in the final EIS.

The other major comment on environmental impact assessment is that the pathways used are not described in enough detail to make an assessment of the thoroughness of the analysis. However, when comparing the dose per curie released used in this report with the dose per curie release from the EPA analysis of the uranium fuel cycle, similar results are obtained. Thus, it appears that the analysis of long-lived isotopes-particularly tritium, krypton-85,

iodine-129-did include the use of long-time -span pathways even though the report does not describe these pathways. However, the population dose commitment estimates presented in the draft statement do not appear to consider world population growth over the time period of the released radionuclides exist in the environment. We feel that calculations of population dose commitments which extend over many decades should take into consideration world population growth during that period.

Several sections of GESMO describe the expected radiation dose from transuranium elements. Information should be included in the final statement which should indicate the pathways for transport of transuranium elements to man. Any differences in chemical behavior assumed for elements other than plutonium should be included.

c. Safeguards

EPA does not have the expertise to evaluate the adequacy of safeguards programs. We do see the issue as a prime factor in the feasibility of a mixed oxide recycle program however, for this reason we do not feel that a commitment should be made to the program until an extensive set of safeguard measures are committed to and the necessary approvals are obtained for their implementation. We hope that other government agencies, such as Justice or Defense where an expertise exists will review these measures to assure their adequacy. As safeguards are such an integral part of the program we would expect that the incurred expense be fully reflected into the cost benefit evaluation. If the devised measures are to be carried out by Federal agencies this should be recognized as a form of government subsidy and either this fact reflected or some means of charging the industry should be arranged.

We are pleased to note that the GESMO includes a lengthy and comprehensive discussion of the safeguards problem; we believe the magnitude of the impact that could potentially derive from a failure of the safeguards system merits this attention. We also concur that continuing study and effort should be devoted to upgrading the safeguards provisions, as outlined in section V-H and elsewhere in Chapter V, and urge the AEC to follow through with their planning in this area.

It should be understood that EPA's comments are based on the premise of no U.S. export of plutonium. The consideration of such an action should be handled as a separate issue. Such a decision should not be taken lightly as it is apparent that a deficiency in safeguards provisions or a breakdown of safeguards in another nation to which we might export MOX fuel, or which moves to plutonium recycle on its own, could effectively negate the safeguards developed in this country. We recognize that such considerations are beyond the

state l scope of the AEC's safeguards objectives. However, we believe that discussions with other nations urging them to implement more stringent physical security measures, mentioned on p V-38, are a vital element in overall safeguards considerations. Effective accountability and physical security safeguards must exist in other countries which utilize plutonium and other SNM if this country's safeguards efforts are to have meaning.

The example calculation on p. V-48 quantifies the risk to selected individuals from a postulated dispersion of plutonium oxide; however, of more interest would be total risk in terms of deaths and cancers, assuming the dispersion occurred in a densely populated area. Also, it would be helpful in evaluating the magnitude of the risk to know what assumptions are used to perform the calculation. For example, is any credit given for evacuation of the affected area? What assumptions are made regarding resuspension? The final EIS should also indicate what kinds of cleanup operations would be required to restore the affected area to a habitable condition.

For the example calculation on p. V-49, of risk from uniformly dispersed plutonium oxide, the area chosen (1/4 acre) is so small that an "inhabitant" would have to be carefully defined. A large area would seem to be more appropriate, corresponding to something less than unity risk for the inhabitants developing bone cancer. Again, total risk should be given for a representative population density, and the bases for the calculation indicated.

III. WASTE MANAGEMENT

Definition of Wastes

The AEC has defined only three catagories of "other-than high-level" wastes; low-level beta-gamma waste, low-level plutonium bearing or alpha waste, and fuel cladding hulls. The present classification system for "other-than" waste, however, gives no indication of the activity, content, or hazard potential of the waste, except that it is not "high-level" waste. The lack of clear definitions for these wastes presents great difficulties for those who ship wastes, for those who receive wastes, and for EPA, particularly, in determining the potential health and environmental impact of the wastes, and we therefore, would like to see the AEC develop a more detailed, formal classification for "other-than" wastes.

Our concerns about the waste classification problem were discussed in EPA's comments on the LMFBR program draft environmental statement and will be discussed in more detail in comments on the Management of Commercial High Level and Transuranium - Contaminated Radioactive Waste draft environmental statement.

Predicated Volumes for "Other-Than" Wastes

There appears to be some discrepancies between the volumes of the "other-than" wastes currently being buried and the amounts predicted in the draft statement EPA has recently completed a preliminary assessment of commercial "other-than" waste volumes, activity, and space requirements(1). In particular the AEC estimates yearly and accumulated quantities of radioactive wastes buried appear to be somewhat underestimated when compared with the results of the EPA assessment. The AEC should re-evaluate their estimates based on the EPA information and other AEC information (2).

The AEC should be more explicit in the final statement concerning the methods used to estimate the volume of future "other-than" wastes from the MOX fuel cycle and how these predicted volumes fit into the total nuclear waste disposal picture. EPA feels that resolution of these points is essential to an evaluation of the environmental impact of the proposed MOX waste management program.

Segregation of Transuranic Contaminated Wastes

"Other-than" wastes from the MOX fuel cycle are expected to be richer in Pu and other alpha contaminants than wastes from the other fuel cycles. This will mean that significant quantities of MOX wastes, which would have been channeled into land burial at commercial burial grounds, would now be placed in interim storage and later transferred to a national repository for disposal or treatment. The economic impact of this policy change on the total costs of power production and on the operations of the commercial burial industry should be considered.

The final statement should indicate the technical arrangements that will be made to screen the "other-than" wastes for transuranium contamination and to prevent the accidental dilution of the transuranium - contaminated wastes to less than 10 nanocuries per gram.

Commercial Burial Grounds

Shallow land burial is the present and proposed method for disposing of the nontransuranic "other-than" wastes. The AEC should present or directly reference in the final statement the results of any studies which have been conducted at the commercial burial sites, subsequent to the beginning of burial operations which could corroborate or validate the conclusions reached in the original evaluation that buried radioactive waste will not migrate from the sites. Also any monitoring data or other evidence which confirms that the radioactive waste now buried has remained immobile at the place of burial should be submitted or directly referenced.

Interim Storage/Ultimate Disposal

While we have significant concerns about the proper execution of the interim engineered storage and ultimate disposal concepts for "high-level" waste we will not include detailed discussion of them in these comments.

We feel that, while they apply to the MOX program, they are more relevant to the draft environmental statement on the Management of Commercial High-Level and Transuranium-Contaminated Radioactive Waste.

Miscellaneous Comments on GESMO: The draft EIS indicated the maximum credible accident at any RSSF to be the rupture of a single cannister. However, since the AEC indicated the possibility of a loss-of-cooling accident, we feel that the environmental impact of this type of accident should be discussed in the same degree of detail as the single cannister accident. These analyses address the additional 30% heat loads and higher radiation levels affect safety margins, facility designs, or costs.

With the increase of total transuranics present in the high-level MOX wastes and the change in the mix of these transuranics, the final statement should discuss how this affects the time required to retain the wastes in some ultimate disposal site and which radionuclides are of primary concern after 10, 100, 1,000, 10,000, 100,000, and 1,000,000 years.

References

1. M. F. O'Connell and W. F. Holcomb, "A Summary of Low-Level Radioactive Wastes Buried at commercial Sites Betwen 1962-1973, with Projections to the Year 200", to be published in Radiation Data and Reports for December 1974.

2. U.S. AEC "The Nuclear Industry 1973, WASH 1174-73

IV. Safety

a. Reactor Plant

The discussion of the relationship of mixed oxide cores to reactor safety margins generally presented qualitative evaluations of the MOX to reactor kinetics and reactor control capabilities. In conclusion the AEC stated that there were no limitations in the use of MOX related to safety. In view of the fact that the draft statement did not consider specific or reference reactor designs, we believe some quantitative details should be presented in support of the conclusion that no safety limitations are necessary. This is particularly important since the MOX, as discussed in the draft statement statement will have both positive and negative impacts on the levels of margin relative to reactor safety. In order to better delineate the overall quantitative aspects of MOX on the level of the margin of safety, we recommend that the final statement assess the overall change in pertinent safety parameters, as itemized in the draft statement, for reference PWR and BWR core designs for several different MOX fuel loadings in the range under consideration. The resulting changes should then be compared, if possible, with the ranges of existing margins in light-water reactors. Although the reference core design may not necessarily be identical to designs or specific reactors, this analysis will enable a conclusion to be reached on quantitative analyses regarding the impact of MOX on safety margins and on the need for specific safety limitations. We assume that, before any operating nuclear plant is licensed to operate with recycle MOX, the AEC will perform detailed safety assessments of the specific core design and will issue an independent safety evaluation report of the results.

b. Transportation

The analysis of transportation accidents appears incomplete since no quantitative information is presented for either the probability of an accident in which radioactive materials are released or the conquences of such an accident. The primary reference used to support the AEC conclusion that the radiation risk is small is WASH-1238 which suffers from a similar lack of quantitative information. In particular, with regard to the probability of an accident involving a release there is no analysis relating the shipping container test conditions to the severity of the accident. Thus, the conclusion that the container should withstand a Category 3 (severe) accident without being breached is not substantiated. With regard to the consequences of an accident involving a release, no estimate of the radiation dose to emergency crews, controversy concerning the quantity of fission products, especially cesium, which may be released is made. An estimate of the external exposure to humans from released radioactive materials was made in WASH-1238. However, it appears the dose to humans from inhalation of the released material may be much greater than received externally.

A complete risk analysis for the shipment of plutonium in DOT approved containers has recently been completed by Battelle Northwest Laboratories (BNWL-1846). This analysis is an important first step in resolving the issues concerning radiation risk in the transportation of nuclear materials. While this study has not yet received the detailed scrutiny of the scientific community to determine its acceptability, it appears to be of sufficient quality to warrant inclusion of its findings in the final statement. A commitment to perform similar analyses for other shipping pathways should also be made in the final statement.

V. FUEL REPROCESSING, FUELS AND REACTOR

Fuel Reprocessing

The iodine-129 and -131 source terms for the model fuel reprocessing plant listed in table E-8 are not in agreement with present estimates by the Oak Ridge National Laboratory based on currently available technology. In the past many uncertainties have been associated with iodine source terms and control technology that will be utilized to obtain the release rates presented in the draft statement. Also the final statement should provide a separate listing in the tables of the doses (both individual and population) resulting from the projected radioiodine releases.

The draft statement does not present information on carbon-14 release rates from either reactors or fuel reprocessing plants.

Because of its long half-life and its persistence in the environment, carbon-14 which has been discharged from these facilities may result in a population dose commitment significantly greater than from either kryton-85 or tritium. Therefore, we feel that the final statement should present the following information on carbon-14:

a. release rates from both reactors and fuel reprocessing plant.

b. local doses and population dose commitments.

c. a discussion of control technology at both reactors and fuel reprocessing plants.

Fuels

The statement is made in several places in the draft EIS (e.g., on pages IV C-20 and IV C-58) that depleted uranium (diffusion plant tails) could be used instead of natural uranium as the diluent for blending with recycled plutonium during fabrication of MOX fuel. This implies a benefit owing to the reduced ore mining and milling requirements and utilization of existing stores of depleted uranium. Elsewhere, however (e.g., on pages I-14, II-44 and II-55) it is noted that natural uranium shows an economic advantage over depleted uranium. The conditions under which stores of depleted uranium might be used, even though such use is described as "uneconomic," should be discussed in the final EIS. If utilization of depleted uranium or tails is not reasonably anticipated the references to such possible use should be deleted.

Reactor

According to Chapter IV, page IV C-73 of GESMO, WASH-1258 (Final Environmental Statement Concerning Proposed Rule Making Action for Operation to Meet Criterion "As Low As Practicable") served as the basis for the source term calculations. However, comparision of the source term parameters in GESMO (Tables IV C-9 and IV C-10) with corresponding tables in WASH-1258 reveal certain discrepancies:

BWR Source Term Parameters

Parameter	Table IV C-9 GESMO	Table 2-1 WASH-1258
Reactor Cleanup Flow Rate	1.54×10^5 lb/hr	1.3×10^5 lb/hr
D. F., Clean Waste Demineralizer	10(10)	1(10)

PWR Source Term Parameters

Parameter	Table IV C-10 GESMO	Table 2-2 WASH-1258
Te Escape Rate Coefficient	1.0×10^{-11}/sec	1.0×10^{-9} /sec
Sr, Ba Escape Rate Coefficient	1.0×10^{-12} /sec	1.0×10^{-11} /sec
Weight of water in primary system	5.5×10^5 lb	5.0×10^5 lb
Weight of water in secondary system	3.7×10^6 lb	4.1×10^5 lb

In addition to these differences in basic source term parametric values, the waste treatment systems assumed for the GESMO model reactors are in may instances unlike those systems presented in WASH-1258. These discrepancies should be clarified with respect to the potential effects on environmental releases.

Table IV C-12 of GESMO has apparently excluded the BWR mechanical vacuum pump (at startup) source term, 2,300 Ci/yr of Xe-133, 350 Ci/yr of Xe-135, and radioiodine (unspecified).

Table IV C-21 and C-22 are apparently mixed-up. Table IV C-12 shows a higher noble gas source term for the UO fueled BWR but doses from this reactor (i.e., skin and total body doses) are lower than the corresponding doses from the mixed oxide fueled BWR. Similarly for radioiodine, a higher source term is listed for the mixed oxide fueled BWR but higher thyroid doses are listed for the UO fueled BWR. It is not clear whether this confusion may have filtered to Tables IV C-27 and IV C-28 for annual man-rem doses.

VI. BENEFIT/COST ANALYSIS

INTRODUCTION

EPA considers the benefit/cost study to be insufficient in detail and depth of analysis. In our opinion, the methodology used is incorrect for a number of reason, which will be discussed in the following sections. Even before correction of methodology the cost savings from plutonium recycle are small relative to nuclear electricity generation costs. There are indications that, if corrected procedures for the analysis were used, the cost savings from plutonium recycle may prove to be smaller than reported.

The debate over recycling revolves around the issues of increased environmental risks to man and the environment, which should be weighed against the benefits to be derived from producing somewhat cheaper power with plutonium recycling. Since risks are balanced against the cost advantages of plutonium recycling, the smaller the cost advantage, the smaller the risks that may be acceptable to society.

METHODOLOGY

The method of analysis employed in the AEC benefit/cost study does not provide the cummulative LWR fuel cycle industry cost figures for the years 1974 through 1995. Table XI-7 does supply cummulative figures for resource and service commitments, but this table is of limited usefulness since it does not include capital costs.

Instead the major thrust of the AEC benefit/cost study is a projection of the LWR fuel cycle industry under various alternatives at a "...mature operating level, about 1990..." The cost figures for this year are in Tables XI-4 through XI-6. AEC chose this year because they believe it represents an "...approximate average industry condition for the time span 1974 - 1995" (p.XI-3).

The methodology used for this AEC benefit/cost study is to measure the fuel cycle costs for a base case, labeled Alternative 1. This base case is then used as a standard of comparison for five alternative cases. The base case represents the reprocessing of the spent fuel and the storage of the plutonium for future use.

Although this methodology appears to be acceptable, since the LWR's will be operating in either case, it is reasonable to suspect that little reprocessing of spent fuel will occurr if plutonium recycle in LWR's is not permitted. With no plutonium recycle, it is likely that most of the spent fuel would be stored for some future use rather than reprocessed within a short time. Such a scenario could lead to significantly smaller impacts in both the reprocessing and transportation areas. We believe that AEC should present more evidence to justify this choice of the base case.

The five alternatives represent different dispositions of the plutonium and uranium contained in the spent fuel. Alternatives 3 and 4 represent plutonium recycling. The difference between these two is that Alternative 4 includes an upgraded safeguards program. The alternatives representing plutonium recycling are the only cases considered that result in lower fuel cycle costs below those for the base case. The AEC's recommended course of action is to proceed with plutonium recycling. Therefore, this discussion of the benefit/cost analysis will be directed towards plutonium recycling.

The benefits to be derived from plutonium recycling are defined as the cost savings gained from plutonium recycling. There are two categories of potential social costs associated with plutonium recycling: those that involve an impact upon the environment and those that have an effect on the level of safety.

Table XI-2 is a summary of the environmental factors for the alternative spent fuel dispositions. No attempt has been made to attach dollar values to these environmental factors. However, it is argued by the AEC that plutonium recycling reduces, to a small extent, the overall impact on the environment. The primary source of this reduction is a decrease in uranium mining, UF_6 conversion and uranium enrichment. In turn, this reduces the need for land and resource inputs, and results in diminished fossil fuel needs. There are some increases in environmental impacts but they are believed to be negligible in comparison to the reduced environmental factors.

The other potential social cost of plutonium reycling is increased safety hazards. Plutonium recycling expands the quantity of plutonium in use in the fuel cycle. This plutonium must be transported and

handled in the process of recycling and is therefore vulnerable to attempted acts of theft or sabotage. The upgraded safeguards program in Alternative 4 is directed towards that danger. Alternative 3 includes a safeguards program much like that for Alternative 1, but extended to take into account the increased quantities of plutonium present with plutonium recycling.

SENSITIVITY ANALYSIS OF SUPPLY AND DEMAND ASSUMPTIONS

Estimates of uranium resources are uncertain. If future nuclear fuel requirements can be met only by the mining of low grade ores, extraction costs will rise above today's level. Plutonium recycle has the potential for somewhat reducing future uranium requirements and costs. The primary source of reduction in costs is the reduction in extraction and enrichment costs, since plutonium can be used as a substitute for a portion of the uranium fuel.

AEC estimates of U. S. uranium resources are shown in Table XI-(A-2). Given the AEC estimates of uranium reserves, and the AEC's estimates of the need for uranium fuel under the different alternatives, the future price for U_3O_8 can also be estimated. These prices are shown for every five-year interval from 1975 through 1995 in Table XI-11. No attempt has been made to determine how sensitive the cost savings from plutonium recycle are to alternative assumptions for uranium reserves, potential changes in enrichment technology, rates of growth of electrical energy demand, rates of substitution of nuclear for fossil plants, or different mixes of nuclear reactors (e.g. HTGRs or HWRs). In our opinion, it seems reasonable to expect that the estimated cost savings shown in Table XI-11 could vary quite significantly if different assumptions were used.

The growth of nuclear power is obviously derived from the overall growth in demand for electrical energy. The overall electrical demand projection used in the AEC Draft statement is based upon Assumption Set D of the AEC projection, Nuclear Power Growth 1974-2000, WASH-1139 (74). That demand projection corresponds to an average annual growth of 6.2% for all electrical power and 21.5% for nuclear power over the period 1970-1995. Growth of electrical energy demand could be much lower (e.g. as low as 4%) as a result of the substantial price increases and

onservation efforts now in progress. There is also considerable ıcertainty about the size of the nuclear share of electricity eneration. This uncertainty arises from recent trends in capital onstruction costs and lower-than-expected reactor availability :perience. The cost savings from Pu recycle can reasonably be assumed o be quite sensitive to these assumptions.

Table 1 shows the eight combinations that EPA considers essential or the sensitivity analysis. The first combination shown represents ıe case analyzed in the Draft EIS.

Two cases for the supply of U_3O_8 are of interest. The first is the ame as projected in the Draft EIS and the second is a 100% increase in :anium resources. This increase would be an additional 100% of the . S. uranium resources (both reasonably assured and estimated ıdditional) corresponding to each price level as shown in Table XI-ı-2).

Two cases for the projected growth in nuclear power are proposed. ıe first would be the same as projected in the Draft EIS and the second ould reflect an average annual growth rate of 4% in electrical power emand and 10% growth for installed nuclear power demand over the period 974-1995. Two cases are proposed for capital construction costs. The irst would be the same as projected in the Draft EIS and the second ould represent a 100% increase in the capital equipment and onstruction costs of all facilities needed for plutonium recycle. This ıcrease would allow for the uncertainties of present day capital onstruction costs.

TABLE 1

SENSITIVITY ANALYSIS

Jranium Supply	Growth in Nuclear Power Industry	Capital Costs
Same as Presented in the Draft EIS	Same as Projected in the Draft EIS	Same as Presented in the Draft EIS
		100% Greater than Presented
	Lower than Projected (4% growth in electrical power) (10% growth in nuclear power)	Same as Presented in the Draft EIS
		100% Greater than Presented
100% Larger than Estimated in the Draft EIS	Same as Projected in the Draft EIS	Same as Presented in the Draft EIS
		100% Greater than Presented
	Lower than Projected (4% growth in electrical power) (10% growth in nuclear power)	Same as Presented in the Draft EIS
		100% Greater than Presented

THE OPTIMAL DATE FOR FULL COMMERCIALIZATION

The EPA believes that the AEC methodology places too much emphasis on the date of introduction of plutonium recycle. There is often a great deal of difficulty in progressing from introduction to full commercialization. The time projections for full commercialization often miss by years. The EPA believes that a better concept to be used in considering the timing of a program is the date of "full commercialization." This is defined to be the time when commercial development has progressed to the point where the future expansion path of the industry can be reliably predicted. Once this point has been reached, there will be comparatively less doubt as to the date a fully developed industry will be achieved. AEC might wish to empirically define the point of full commercialization as the point when recycled plutonium accounts for more than X percentage of LWR fissile fuel.

If plutonium recycling is fully commercialized too early, the price of uranium will still be too low, decreasing the discounted present value of cost savings derived from plutonium recycle. Delay in the date will increase the discounted present value of cost savings. However, if plutonium recycle is fully commercialized too late, future cost savings will occur too far in the future and their discounted value will be smaller than if the date were moved earlier in time. Thus, the discounted present value of the cost savings from plutonium recycle will first rise and then fall as the date of full commercialization is moved outward in time. The optimal date for full commercialization is the date for which the present discounted value of cost savings is maximized.

The Final EIS should include calculations of the present discounted value of cost savings for each different date. These calculations should be performed not only for base case parametric conditions, but also for the other sensitivity cases identified in this review. In order not to bias the analysis against later full commercialization dates, it will probably be necessary to extend the ending period of the analysis past 1995.

COST SAVINGS AND THE CROSSOVER POINT

The EPA believes that early initiation of plutonium recycle requires the demonstration that the savings are significant in comparison to nuclear electrical generation costs and that they are realized early in the recycle program. Deferred initiation of plutonium recycle should be considered to be an alternative if the cost savings are not realized early in the fuel recycle program. The remainder of this section provides the framework for this argument.

First, it should be demonstrated that there are savings from plutonium recycle. They should be apparent from the analysis of the cumulative costs of operation for the period 1974-1995. These savings should be realized for the whole program, including reactor costs as well as fuel cycle costs. In addition, these savings should be large enough to warrant the additional risks inherent in plutonium recycle. As discussed elsewhere in this review, the draft EIS does not satisfactorily describe or quantify the costs of an adequate safeguards program. Some safeguards measures (e.g. spiked plutonium) may substantially increase the costs of plutonium recycle. These costs are difficult to predict, and could be considerably higher than the AEC presently estimates.

If analysis demonstrates that there are substantial savings from plutonium recycle, steps to proceed immediately are justified only if it is shown that the savings derived will begin soon after the program is implemented. In order to determine how soon plutonium recycle reaches this point, which can be termed the crossover point, an analysis of the costs of operation of each alternative, on a year by year basis is needed.

EPA considers the determination of the crossover point to be quite important. If this point will not be reached until many years in the future then there is less incentive to make a present commitment to the future use of plutonium recycle for routine fueling of LWR's. A more limited present commitment could be considered without foreclosing the future option of using routine plutonium recycling. The crossover point concept could be usefully incorporated into sensitivity analysis.

PRIORITY USE OF PLUTONIUM

AEC gives first priority to the production of the plutonium needed to fuel fast breeder reactors. Therefore, 26% of the plutonium produced in LWRs over the time span 1974-1995 is to be withheld from plutonium recycle for that purpose. The choice of the 26% figure is not explained or justified, except to state that there will be large quantities of plutonium left over after meeting the requirements for the first fuel loadings for the new breeder reactors. Since the savings from plutonium recycle is responsive to changes in the fuel cycle, EPA believes that the Final EIS should explain how the 26% figure was determined because there can obviously be important environmental consequences from saving different percentages of LWR-generated plutonium. The interrelationship between the fast breeder reactor program and plutonium recycle will be explored in the Appendix which describes a method that can be used to determine the appropriate amount of plutonium to be withheld from recycle for the fueling of fast breeder reactors.

THE ROLE OF THE HTGR

There is virtually no discussion of the role of the HTGR in the nuclear reactor field through 1995. Figure S-1 and Table VIII-2 shows that it is expected to make a relatively small contribution. An obvious question is whether or not the cost advantage to plutonium recycling is sensitive to the relative mix of LWRs and HTGRs. Some supplementary analysis could be usefully employed to pursue this question.

DISCOUNTING

No discounting has been used in assembling the data for Tables XI-4 through XI-7. Therefore, there is no adjustment for the fact that capital and operating expenditures take place at different times. For example, the capital in place in 1990 will be composed of a mix of capital of various ages. The accepted procedure for taking this into account is to use discount rates to evaluate time distributed costs and benefits in present value terms. This procedure is described in Circular A-94, Revised, issued by the Office of Management and Budget. This circular requires the use of a 10% discount rate.

It is impossible to determine with the present analysis precisely what discounting will do to the apparent cost savings gained from plutonium recycling, for the changes in the present value are functionally related to the time-distribution of expenditures. Time distributions of cost data are not provided in the Draft EIS. However, if the time distribution of expenditures is roughly the same for the alternative cases, it is to be expected that the use of discounting would reduce the absolute size of the cost savings that can be attributed to plutonium recycling. Table XI-6 shows the fuel cycle costs for the year 1990. There appears to be one billion dollar saved from plutonium recycling as compared to the base case. Since no discounting has been used, the corrected value of this cost savings cannot be determined.

The failure to discount to present value leads to even greater misconceptions when considering Table XI-7. This table is a tabulation of expenditures for resources and services for the period from 1974 through 1995. These expenditures do not represent any capital investment over this period, just the expenditures for resources and services incurred in operation each year. Since the costs of operation are not discounted for future years of operation, the contribution for those years in the distant future are much greater than they would be if evaluated in present value terms. With discounting, the differential costs for each alternative dispostion of plutonium would be reduced in a like manner, thus decreasing the magnitude of the apparent cost savings when plutonium is recycled.

Since no time-specific cost data is provided in the draft statement it is impossible to determine how much the cost savings claimed exceed those that would be incurred if evaluated in present value terms. In our opinion, they could be substantial. The nuclear power industry is projected to grow continuously through 1995, so that the total operating expenses for each of the six alternatives will be larger in the later years of the period evaluated. Therefore, these later years make the greatest contribution to the expenses recorded in this table. But the expenses for the later years are the ones that will be subject to the greatest discount. The present value of the cost savings may be greatly reduced from those recorded in the table.

SAFEGUARDS COSTS

The safeguards program is described in Chapter V of the Draft Statement and its costs are estimated in Chapters VIII and XI. A wide

variety of safeguards programs are discussed. Some have estimates of costs attached to them, others do not. The measures considered include the incorporation of integrated fuel cycle facilities which would reduce transportation requirements, a Federal security force that would not be restricted by state and local limitations and could respond on a nationwide basis if necessary, hardening of barriers against theft and sabotage, suggested protection of transportation functions, spiked plutonium, and a variety of other measures. Since the particular form of the safeguards program is not resolved in the Draft EIS, the costs of implementation cannot be determined with certainty. AEC states that the cost figures are to be used to "...give a perspective, a point of view and an order of magnitude for these costs." AEC maintains that these costs would be small enough that they would not be a significant economic consideration.[1] The remainder of this section and the next section of this EPA review demonstrate that the estimated costs of these safeguards programs are large enough to have an impact on the economics of plutonium recycling.

In the summary of Chapter XI, under the discussion of Materials and Plant Protection Considerations, p.XI-19, it is stated that although "...projected materials and plant protection costs in 1990 will be significantly higher for Alternative 4 than for the base case, the resultant effect on the overall economics of the fuel cycle is judged to be inconsequential." This statement is in reference to an upgraded safeguards program, estimated to cost 74 million dollars in 1990. This cost is indeed small when compared to the total fuel cycle costs. However, it is much larger in comparison to the costs savings incurred in 1990, representing approximately 6% of the cost savings attributable to plutonium recycling without safeguards (Table XI-6, Alternative 3). For this reason EPA suggests that the term "inconsequential" is not an appropriate descriptor of potential safeguards costs.

SPIKED PLUTONIUM

Spiked plutonium is discussed in various places in the draft environmental impact statement, but has not been included in estimated costs of materials and plant protection. Nowhere is its use explicitly

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[1] See page VIII-75.

rejected. The reader is left with no definite indication whether spiked plutonium is considered to be a likely additional safeguard measure.

The cost of incorporating spiked plutonium is estimated to be 170 million dollars for the year 1990 and to be in the order of three billion dollars for the period through 1995.[2] By telephone inquiry, the EPA was informed that spiked plutonium was not included in the fuel cycle since its cost is small compared to total fuel cycle costs. However, comparing these costs to total fuel cycle costs is not relevant. Spiked plutonium costs are more appropriately compared to the savings associated with plutonium recycling. Inspection of Table XI-6 reveals that the inclusion of spiked plutonium as an additional safeguard will lower the cost advantage of Alternative 4 from 980 million dollars to 810 million dollars, a reduction of 17%. If spiked plutonium is some day determined to be a necessary safeguard measure, its use will significantly reduce the cost savings derived from plutonium recycling.[3]

STANDARDS FOR COMPARISON OF COST SAVINGS

In Table XI-6, AEC calculates the cost savings from Alternative 4 to be approximately one billion dollars as compared to the base case, for the year 1990. This cost savings results in a calcualted savings in "Total Operating mills/kwh" of 3.89-3.54=0.35 mills/kwh. These costs are not busbar costs, for they include only fuel cycle costs. Costs not contributed by the fuel cycle have not been included in Table XI-6. There is a question as to the appropriateness of not giving an estimate of the busbar costs. An uninformed reader of the Draft EIS might assume the reported costs represent the total costs of generating electricity, and arrive at the incorrect conclusion that the cost savings from plutonium recycle represent approximately a 10% savings (i.e. 0.35 mills/kwh saved from a base cost of 3.89 mills/kwh).

The 1974 busbar cost of generating electricity is approximately 16 mills/kwh. The cost savings for Alternative 4 as compared to Alternative 1 could then be calculated to be (3.89-3.54)/16 = .022 or approximately 2.2% of the total costs.[4]

When the savings for plutonium recycle are viewed as a component of total nuclear power generating costs, they are much smaller than they

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[2]This estimate is found on page VIII-75. A contradictory estimate of its cost is found on page V-45. Inquiry of the AEC established that the correct figure is 170 million dollars.

[3]No discounting has been used here, because the necessary data is not available in the Draft EIS.

[4]No discounting has been used here, because the necessary data is not available. However, the use of discounting would not change these conclusions.

.re when considered as a component of fuel cycle costs only. It is .mportant to view the cost savings from this perspective. Should it)ecome necessary to forego plutonium recycle someday, because of some :nvironmental or safeguards problem, it is clear that the absence of)lutonium recycle would have only a marginal impact on electricity :osts. EPA recommends that AEC consider total LWR busbar costs to be :he appropriate standard against which the cost savings from plutonium :ecycle be compared. This standard of comparison would be more .eaningful to a reader of the final EIS. The Final EIS should at least .nclude this kind of comparison, and it should be given equal prominence vith the comparison to fuel cycle costs presented in the Draft EIS.

:ONCLUSION

The methodology used to compare the costs of using recycled)lutonium to the base case of not recycling can be significantly improved. There is considerable reason to believe that the cost savings from plutonium recycling may not be as large as shown in the Draft EIS. EPA recommends that all the calculated costs of alternative spent fuel dispositions be redone with all expenditures discounted to 1974 values. Discounting is the only way to bring expenditures that take place in different time periods into proper perspective.

It is further recommended that the capital and operating costs of reactors be included in the costs of six alternatives. This will make it possible to judge all cost savings in relationship to the total costs of using nuclear reactors to generate electricity.

EPA also recommends that the sensitivity analyses described in an earlier section of this review be incorporated into the benefit/cost study so that readers of the Final EIS will be able to determine how sensitive the cost savings from plutonium recycling are to changes in the growth of electrical energy demand, changes in the uranium resources, and changes in the estimated capital costs of mixed oxide facilities.

The EPA does not consider the analysis of fuel cycle costs for only one year, 1990, to be adequate for judging the merits of plutonium recycle. This would be true even if the analysis were methodologically correct. The cumulative costs for the years 1974 through 1995,

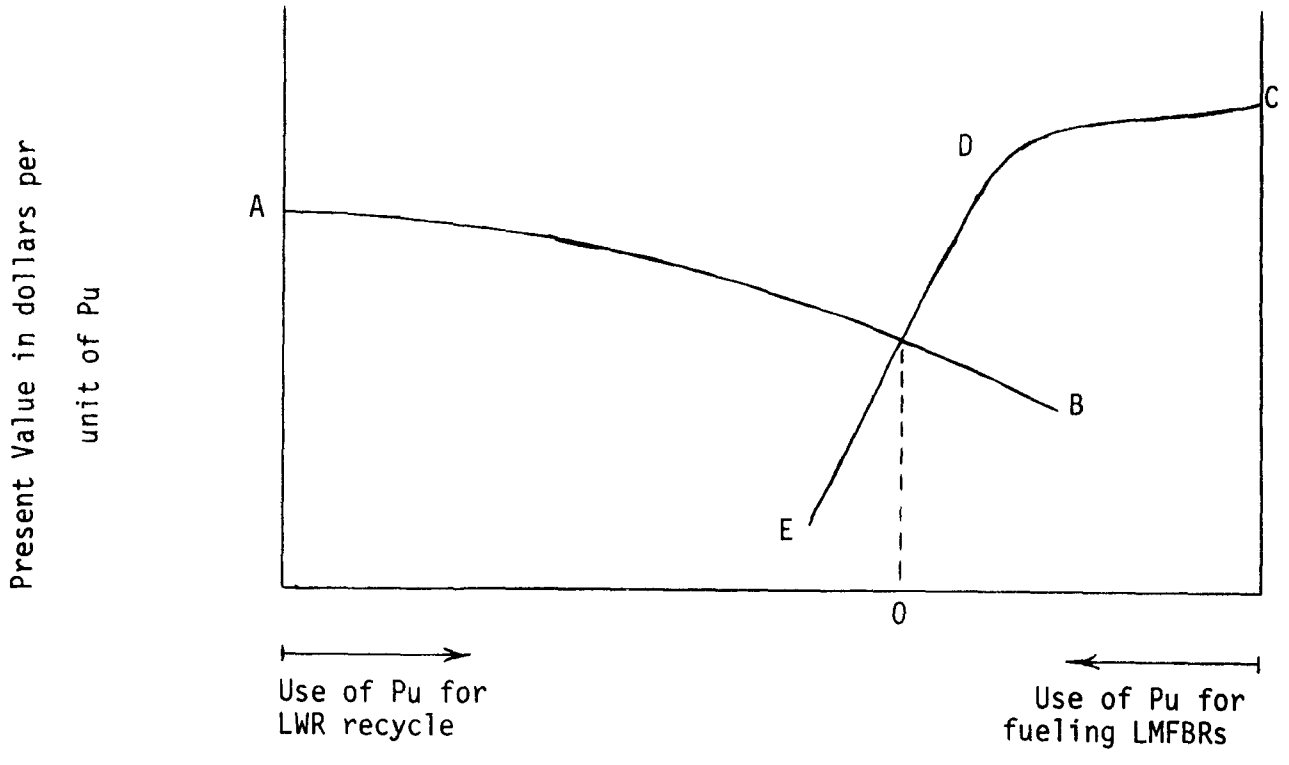
appropriately discounted, must be shown for each alternative. The information the AEC provides in Table XI-7 is not sufficient, for it does not include capital costs.

The Draft EIS does not adequately treat the subject of the economic timing of the commercialization of plutonium recycle. Timing is very important because new information is continually being developed in the areas of plutonium toxicity, the costs and feasibility of safeguards measures, and the magnitude of transportation hazards. Thus, the Final EIS should contain a thorough analysis of when the cost savings of plutonium recycle are expected to begin and how large they are likely to be. This information will be highly useful to interested groups and could be a valuable input to future public discussions about the timing of plutonium recycle.

APPENDIX

It is assumed here that uranium resources, the growth of the nuclear power industry, and the date of LMFBR introduction are all given. The horizontal axis in Figure 1 represents units of plutonium. The total horizontal dimension represents the total amount of plutonium generated from LWRs. Movement from left to right represents more use of plutonium for LWR recycle and less use for LMFBR fueling. Movement from right to left, on the other hand, represents more use of plutonium for LMFBRs at the expense of LWR recycle. Each point on the horizontal axis represents a different allocation of plutonium between plutonium recycle and fuel for LMFBRs. The verticle axis measures the present value of a unit of plutonium.

Figure 1



The line AB represents the preset value of plutonium used in LWR plutonium recycle, and is expressed in dollars per unit. The downward slope of the line reflects the fact that the present value of each additional unit of plutonium will decline as the amount of plutonium used in recycle increases for any given year. This is because plutonium replaces uranium as a fuel in LWRs and the higher cost uranium ores will be the first to be replaced by plutonium.

The line CDE represents the present value of plutonium used for fueling LMFBRs, and is expressed in dollars per unit. The downward slope of this line (moving from right to left) reflects the fact that the present value of each additional unit of plutonium will decline as the amount of plutonium reserved for fueling LMFBRs increases. The "kink" in the line is to indicate that there may be a minimum amount of plutonium needed to satisfy the rapid rates of LMFBR commercialization projected by the AEC.

Point "0," where the two lines cross, represents the optimal distribution of plutonium between plutonium recycle and fuel for LMFBRs.

EPA does not consider it unreasonable to ask that the above type of analysis be performed. The only significant obstacle to performing such an analysis would be the present uncertainty about the dates and rates of LMFBR introduction. This obstacle can be overcome by using the dates and rates specified in Table 10.4 in Volume III of the AEC Draft Environmental Impact Statement for the LMFBR Program (WASH-1535).

VII. ADDITIONAL COMMENTS

1. Tables IV C-12, IV C-21 and IV C-22 are not consistent; e.g., MOX skin doses are higher but for the mix of noble gases in effluents given, they should be lower. Also, while iodines in MOX gaseous effluents are shown higher, thyroid doses are lower.

2. Figure IV C-24 does not appear to be drawn correctly. The reduced central temperature in the MOX rod is stated to be a consequence of the higher neutron cross section of Pu, which causes a higher peripheral heat generation rate and lower central flux. This being the case, one would expect the termperature profile of the MOX to be higher in the periphery, reflecting the increased heat flux at that location.

3. No mention is made of the magnitude of possible tramp plutonium problems with MOX fuel. This should be addressed in the final statement.

4. Another possible alternative that should be considered relative to the timelessness of initiating a mixed oxide recycle program in LWRs is the diversion of surplus enriched weapons uranium to such utilization as naval reactors. While the diversion may be completely infeasible such a move make available present inventories of new uranium and enrichment capacity to LWRs alleviating short term shortage problems. Because of the interest in such trade offs, this alternative should be discussed in the final EIS.

5. Vol. 1, Pages S-38 to S-40: Table S-8
The titles of these two tables refer to two fuels being considered but only one set of numbers is given.

6. Vol. 2, Page II-29, last sentence of part b: This sentence is not totally true. Some plutonium has been left in wounds when surgery was expected to result in a worse situation than by leaving the plutonium there.

7. Vol. 2, Page II-29, part c: This part could be made specific for environmental radioactive material received into the body via inhalation or ingestion. Wound or injection entry is of little concern in the environment, but important for occupational workers.

8. Vol, 2. Page II-32, part j; and Vol. 3, Page IV. J (c)-1 last sentence: There are data available which suggest an increase with time in plant plutonium uptake from soil. (See J. Environ. Quality, Vol. 2, No. 1, 1973, and Health Physics Journal 19:487-491, 1970.) These data should be discussed here.

9. Vol. 3, Page IV. A-13, last sentence of second paragraph: the standard referred to in this sentence should be referenced or discussed. Such a standard has not been, to our knowledge, proposed by a recognized radiation standard setting group.

10. Vol. 3, Page IV. J. (A)-9: The numbers used in the population dose commitment equation cannot be considered conservative since higher P/A and lower deposition velocity values have been strongly suggested. Both of these trends would increase the dose.

11. Vol. 3, Page IV. J. (C-7, second paragraph: The ingestion pathway should not be dismissed as a potential pathway for exposure to actinides. If gut absorption increases and plant uptake increases (both are possibilities), then this pathway could be as important as important as the air pathway.

12. There is apparently a contradiction in philosophy concerning fission-gas-release in MOX fuels (p. IV C-51). Since this aspect is related to fuel rod performance (and safety) characteristics, the question of significant or insignificant increases in fission-gas-release should be resolved and included in the final statement.

13. p. IV J (A)-2 A semi-infinite cloud dose calculation was utilized in WASH-1327 to compute the dose due irradiation by nuclides in the atmosphere. A comparison of external gamma whole body dose calculations using finite and semi-infinite cloud dose models is presented in EPA-520/1-74-004(1). It is noted that at close distances to the facility stack a semi-infinite cloud assumption results in a very low ground level concentration and gross underestimates of dose since it ignores gamma rays emanating aloft. Therefore, a finite cloud rather than a seminfinite cloud dose model should be utilized to compute close in external doses from evaluated atmospheric emissions of radionuclides.

14. p. IV J (A)-2 A value of 7mg/cm was assumed for the density thickness of the dead layer of the outside of human skin in computing " the beta dose. New values of epidermal thickness are reported by Judi T. Whitton (2) and it is recommended that "for radiological protection purposes it is appropriate to replace the value of 7mg/cm , currently used for minimal epidermal thickness on all body sites, by a value of 4mg/cm for average epidermal thickness." We concur with the recommendation by Whitton.

15. In determining the dose rate from airborne beta radioactivity, it is stated that a graph (Fig. 7.5, Meteorology and Atomic Energy, 1968, p. 332) was utilized to determine the maximum beta rad dose versus maximum beta energy through a 7mg/cm absorber. Because of an error in the apparent absorption coefficient, the dose at a depth of 7mg/cm is low in Fig. 7.5 of Meteorology and Atomic Energy, 1968 (3). The depth dose values in Figure 7.5 utilizes results from equation 7.25c on p. 331 (3) which is in error by a factor of 2. The correct simplified expression for the apparent absorption coefficient obtained from Loevinger, et al. (4) is as follows:

$$v = \frac{18.6 \text{ cm}^2/\text{gm}}{(E - 0.036)^{1.37}}$$

where v = apparent absortion coefficient
E = maximum beta energy emitted

Therefore, the low beta depth dose values presented in WASH-1327 should be recomputed based on an average epidermal thickness of 4mg/cm and corrected apparent absorption coefficient values. The graph on p. 332 of Meteorology and Atomic Energy, 1968 (3) should not be utilized for depth dose values.

16. pp. IV J (A)-3-4 Since the INREM computer code was used to compute the 50-year dose commitment from the inhalation and ingestion of radionuclides, the pertinent assumptions utilized in this code should be presented in WASH-1327. The information presented in WASH-1327 regarding INREM is not complete enough to allow an evaluation of dose assessment

techniques to be made so conclusions cannot be reached regarding the validity of the presented dose commitment estimates in WASH-1327. A complete copy of the code with an explanatory text should be made available to all reviewers so that an evaluation of the INREM dose assessment techniques can be made.

17. pp. IV J (A) -7-8 In the analysis of the aeolian pathway, only the Pasquil D dispersion regime was considered in computing the generalized aeolian dilution factor values. Ignoring other representative dispersion regimes significantly underestimates the annual average χ/Q value for the 100 m chimney release at 500 meter downwind. More representative assumptions would result in a value of similar magnitude to those presented for downwind distances of 1, 1.3, and 2.5 kilometers. Reference 5 presents annual average χ/Q values at 500 meters for 25 LWR site regimes and an average value of 6.157 x 10 sec/m is reported for a 100 meter release hight. The 500 m value for the m chimney release in Table IV J-(A.1) should be modified to reflect more reasonable dispersion values and any dose calculations made using this dilution factor should be corrected since they underestimate the dose by approximately 10,000.

References for comments 14-17:

1. Martin, J. A., C. B. Nelson, and P. A. Cury, AIREM Program Manual- A Computer Code for Calculating Doses, Population Doses, and Ground Depositions Due to Atmospheric Emissions of Radionuclides, Office of Radiation Programs, U.S. Environmental Protection Agency, Washington, D.C., EPA-520/1-84-004 (May 1974).

2. Whitton, Judi T., "New Values for Epidermal Thickness and Their Importance, "Health Physics, Vol. 24, pp. 1-8 (January 1973).

3. Slade, D. H., ED., Meteorology and Atomic Energy 1968, U.S. Atomic Energy Commission/Division of Technical Information (July 1968).

4. Loevinger, R., E. M. Japha, and G. L. Brownell, "Discrete Radioisotope Sources," Chap. 16, Radiation Dosimetry, Academic Press Inc., New York (1956).

5. Final Environmental Statement Concerning Proposed Rule Making Action: Numercial Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion "As Low As Practicable" for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents, Prepared by the Directorate of Regulatory Standards, U.S. Atomic Energy Commission, Vol. 1, p. 6B-32, Table 6B-2, WASH-1258 (July 1973).

18. Page IV H-2; lines 26 and 27

Indicate the basis for the waste generation rate of 4 x 10 ft per year and the burial ground acreage requirement. These values appear to be quite different from numbers obtained from WASH-1539 and ORNL TM-3965.

Page IV H-4; Accident and General Exposure Sections

Indicate or reference the basis used for the factor numbers and original dose numbers.

19. Page IV H-4; Accident and General Exposure Sections

Indicate or reference the basis used for the factor numbers and the original dose numbers.

20. Page IV H-7; Uranium Mills Section

Indicate the basis used for calculating the curie release.

21. Page IV H-10; line 20

Indicate basis for volume and radioactivity of waste generated in 1990.

22. Page IV H-32; lines 6 and 7

Indicate other kinds of low-level liquid wastes which will be produced and why they can't be cleaned up and recycled. In considering solidification indicate other alternatives which are available besides cementing.

23. Page IV H-39; lines 13-15

Could the radioactive liquid wastes be recycled? In considering solidification indicates other viable alternatives available besides cement.

24. Page IV H-40; lines 4-6

After the processing of the contaminated water for the removal of radioactivity indicate what is done with the processed water. Indicate what methods and limits will be used to distinguish between uncontaminated and contaminated water.

25. Page IV H-46; lines 14 and 15

Since the AEC is eliminating the routine use of surface and near surface techniques that depend on soil to remove radioactivity from liquid wastes (WASH-1202-73 p. 27) the statement concerning high absorptive capacity of the soil should be further clarified as perhaps a 3rd or 4th order protective device and not as a secondary backup as might be inferred.

26. Page IV H-51; line 25

Show the basis for the assumption of waste radioactivity concentration of 0.003 Ci per ft .

27. Dose calcuations for the dropping and rupture of a waste canister at the Retrievable Surface Storage Facility (RSSF) are made at a distance of 5 miles from the facility stack. This 5 mile distance is stated to be the closest assumed access for a member of the public. If this 5 mile exclusion distance is not a documented siting policy for the RSSF then dose calculations should be presented for distances closer to the facility stack. As a minimum, the reason for the use of the 5 mile exclusion distance should be presented.

28. It is not made clear in the EIS the extent to which plutonium is or is not the dominant environmental consideration. A thorough discussion of the sources, biological availability, and the metabolism of the transplutonic isotopes would be helpful for evaluation of the EIS. Durbin has presented data on the differences in metabolism of transplutonic elements (P. W. Durbin, Distribution of the Transuranic Elements in Mammals, Health Physics 8:665-671 1962). Additional information on distribution and metabolism variations both by isotopes and by species and age for plutonium and transplutonic isotopes can be found in the Proceedings of the Hanford Symposium on the Biological Implications of the Transuranium Elements Health Physics 22 #6, 1972. Implications of these differences should be included.

29. Page IV, J-2. Because only fatal cancers are enumerated in the EIS, the somatic health effects listed underestimate the projected impact by a factor of two. If the total cancer incidence, not just cancer fatalities were included in the EIS, an additional perspective would be provided.

30. Page IV, J-3, Table J-1, there is evidently a misprint. Appendix A to Chapter IV-F is limited to some effluent information pertinent to the uranium mining and/or milling industry; but it does not give the basis for the man-rem number listed in the succeeding Tables.

31. Page IV, J-7 c, second paragraph. Differences between the physical and chemical characteristics of Pu fallout and particulate Pu from mixed oxide fuels should be described so that the reader can judge the relevancy of fallout plutonium to the problem of interest here. Indeed it would be helpful to discuss the particulate nature of Pu in mixed oxide fuels early in the Chapter.

32. Page IV, J-7c, third paragraph. ICRP #6 page 8 would seem to contradict the conclusion that the absence of a consideration of hot particles is a satisfactory state of affairs to standard setting bodies. The Los Alamos reference offered for the assertion given in the EIS is inadequate support for this assertion in view of the statement by Sanders, Thompson and Bair in AEC Symposium Series 18, "Nonuniform irradiation of the lung from deposited radioactive particulates is clearly more carcinogenic than uniform exposure (on the basis of total lung dose), and alpha radiation is more carcinogenic than beta irradiation."

33. Page IV, J-8, second paragraph. This one sentence paragraph could mean that either the particulates in MO fuels are not subject

to accidental distribution or that no health consequences due to particulates would follow such an event. Either way, this important conclusion should be discussed in full with better documentation.

34. Page J-14, Table J-13. In view of the possibility (see earlier comment) that the increased dose from mixed oxide fuel fabrication and reprocessing does not out weigh the reduced dose from less mining use of the label of "Risk Reduction" may be premature.

35. Page IV, J(A)-2. From the text in "Meteorology and Atomic Energy" it would appear that the Fig. 7.5 (ibid) referred to here was based on an incorrect calculation of beta-ray attenuation in skin. The sensitivity of the results presented to this error should be evaluated or better yet use Martin Berger's more recent calcuations in Health Physics, Vol. 26, No. 1, January 1974,

36. Page IV, J(A)-3, second paragraph. Applicability of data from the "particular plot of ground" at ORNL to rest of the United States should be discussed in terms of soil characteristics, climate, cropping practices, etc., so that the importance of this study can be placed in perspective by the reader.

37. Page IV, J(A)3. The estimate of environmental concentrations of I-127 and H (water vapor) are quite critical to the final risk evaluations and should be documented in full. Variations in these parameters could affect large portions of the population, for example persons living in regions with iodine deficient soils. Perhaps those cases should be discussed also.

38. Page IV, J(A)-4d, first paragraph. The breathing rate used is for a "reference man." Consideration should be given to other members of the population also. Were women and children not considered?

39. *Ibid, 1, fourth paragraph.* That the range of resuspension varies between 10^{-2} - 10^{-13} should be referenced to the original source documents. It is not clear that this range is appropriate for plutonium in the environment or that 10^{-13} has been verified experimently.

40. Ibid, 1, last paragraph. Has the purported decrease of resuspension with time been observed in areas other than desert type such as used for bomb testing? Changes in the amount of resuspended plutonium in the vicinity of Rocky Flats, which is more likely to be similar to the problem of interest here, would help show the general applicability of these data. In addition, particulate resuspension in urban and suburban areas should also be considered in the EIS.

41. Page IV, J(A)-5, fifth paragraph. If the longest study of resuspension decreasing with time is, as reported in the EIS, eleven months, the 50 day half life used here corresponds to a reduction of about 30 in plutonium resuspension. The applicability of such data to a reduction of 100,000 (as is done in this EIS) should be justified by an appropriate analysis, since the magnitude of the lung doses is quite sensitive to the resuspension variables.

42. Page IV, J(8)-8. AEC reports documenting the k factors used to calculate dose are not described in the EIS. The selected conversion factors may be valid but there is no way of examining the underlying assumptions used in their development.

43. Page IV, J(B)-1, first paragraph. Animal experiments have identified the need to know the physical and chemical forms of the transuranics since any anticipated distribution is closely related to these questions. Animal experiments have also identified definite species differences which make extrapolation to man uncertain. As pointed out by Engel (S. Engel, Comparative Anatomy and Pulmonary Air-Cleansing Mechanisms in Man and Certain Experimental Animals, Health Physics 10:967-971, 1964): "I should like to stress that neither the lung of the dog nor cat are typical examples of the mammalian lung. In other words, if either animal is used for laboratory experiments, this fact must be borne in mind." Current studies on morphometrics of the lungs of experimental animals at Lovelace Foundation show definite differences between man and dogs, rats and hamsters. The differences include branching angles, branching angle as a factor of parent airway diameter and functional anatomy. (Respiratory Tract Deposition Models Project Staff Reports, Dec. 1972, March 1973, July 1973 and April 1974). Additional information on species age and isotope interrelationships can be found in the Handbook of Experimental Pharmacology XXXVI, Uranium•Plutonium•Transplutonic Elements, Springer-Verlog, New York, 1973. Particularly Chapter 10 (Distribution, Excretion and Effects of Plutonium asa Bone-Seeker) and Chapter 18 (Metabolism and Biological Effects of the Transplutonium Elements). Perhaps, the relevance of animal data to the problem of interest here should be critiqued so that the reader will not read too much into the reported results.

44. Page IV, J(B)-1, third paragraph. The body of data on distribution and retention of ^{239}Pu in man is severely restricted by the fact that only selected tissues have been analyzed and they may not be the appropriate ones. Transuranium Registry data show that any of a wide variety of tissues may have the highest organ concentration of plutonium and until sufficient data are obtained it

will be difficult to adequately assess the problem in man (United States Transuranium Registry Summary Report to June 30, 1974, HEHF #22, 1974).

45. Ibid, last sentence. Comparative pathology is not so far advanced that one can assume that pathological changes observed in animals are a true or adequate picture of the hazards to man from transuranics. For example the majority of lung malignancies reported in animals after plutonium inhalation are adenocarcinomas or other peripheral cancers. However as Kuschner points out:

> I feel very strongly that the term tumors of the lung is an unfortunate one. Even cancer of the lung is an unfortunate term. I think all of us here know that cancer is a disease of a tissue, not of an organ. There are particular determinants that relate to the production of a bronchogenic carcinoma that probably do not hold for tumors of more peripheral sites.
>
> I believe that we can study the mechanism of malignant transformation and the factors that relate to it in any part of the body and in any tissue. Perhaps peripheral lung tumors are a convenient method of doing this, but they don't relate to the immediate problem; that is, what are the particular factors that go into the induction of - and the pathogenesis of - bronchogenic carcinoma in humans.
>
> It is for this reason that I think the induction of pulmonary adenomas, or adenocarcinomas, is not pertinent to the lung tumor problem. They are pertinent to the tumor problem, but not to specific induction of the lung tumor that we are concerned with, bronchogenic carcinoma.
>
> I think it might be important, too, in regard to Dr. Sanders' presentation these Proceedings, pp. 285-3031, to point out that as far as I know the tumors produced by J. F. Park and by C. L. Yulie were all peripheral tumors of alveolar orgin. Some of the dosage inconsistencies between alpha and beta emitters which did produce bronchogenic carcinoma might perhaps be explained by the fact that we are dealing with a different tissue.

(S. Laskin, M. Kuscher and R. T. Drew, Studies in Pulmonary Carcinogenesis, pp 321-351 in Inhalation Carcinogenesis, AEC Symposium Series #18, 1970). Also a discussion of the comparative pathology of "lung tumors" is presented on pp 467-472 of the Panel Discussion in Morphology of Experimental Respiratory Carcinogenesis (AEC Symposium Series #21, 1970). The use of such data to evaluate health effects in humans should be fully explained.

Page IV, J(B)-2, third paragraph. The statement in the EIS that "Unfortunately no evaluation of economic cost that might be due to the linear assumptions, as compared to other assumptions, has yet been done" might be more appropriate in the cost-benefit section. The idea that the dose-risk relationships used to evaluate potential health impacts from nuclear energy should be subject to a cost benefit analysis has important public health policy implication and should either be explored further in a "generic" impact statement of this type or deleted.

46. Page IV, J(B)-4. The genetic effects calculations referred to in Table IV, J(B-1) and in the fourth paragraph are adequate for a population which replaces itself in a 50 year period, that is the replacement rate (birth rate) is 2% per year. If the birth rate is more than 2% per year or less than 2% per year these genetic risk estimates will proportionately increase and decrease accordingly. This should be stated.

47. Page IV, J-(B-4), second paragraph. Reference if any should be cited for the zero effects estimates and the value of the assumed threshold dose rate used here.

48. Page IV, J(C)-7, 2, first paragraph. The statement that the BEIR report calculates average dose and estimates tumor incidence on the basis of the uniformly irradiated lung is inaccurate. BEIR report lung tumor estimates are based on the radiation dose to cells of the bronchial epithelium and it is explicitly so stated. (BEIR, Summary of Risk Estimates for Bronchial Cancer, p. 150). The specific risk estimates are for irradiation of the basal cells of the bronchial epithelium as indicated in the BEIR report (p 148, p 154 BEIR Report). This EIS should be corrected to accurately reflect what the BEIR report says of the BEIR report is referenced.

49. Page IV, J(C)-8a. Since the sample size in the Las Alamos study referred to makes a negative finding almost inevitable, the probability of a type II statistical error, false negative, should be given to avoid possible erroneous conclusions. Rough calculations using values of 1 rad/year bone exposure and 8 rad/year lung exposure

(the approximate average annual dose rate for the maximum accumulated organ dose reported in A Twenty-Seven Year Study of Selected Los Alamos Plutonium Workers, LA-5148-MS, 1973) yield an annual dose estimate of 250 man rem in bone and 2000 man rem in lung for the 25 workers in the Los Alamos study.

Using BEIR report risk estimates there would be an annual risk of 8×10^{-2} lung cancers and 3×10^{-3} lung cancers in the workers. If the 1966-1968 Connecticut Tumor Registry mortality data are used the follow-up time required to observe a radiation related increase in mortality can be calculated.

To observe a difference in exposed and a normal populations at the 90% level a 33 year follow-up would be required in the lung cancer and a 667 year follow-up in the bone cancer evaluations. For a 95% level 53 years and 1098 years respectively would be required.

The follow-up time required would be further increased by the length of the latent period before induction of the cancer. If a 20 year latent period is used the difference between exposed and a normal population, if present, probably would not be identifiable until the year 2020, a period of time beyond the expected lives of those workers discussed in the Los Alamos Study.

The low relevance of negative findings in the Los Alamos Study population at the present time should be explained to put the information in perspective.

50. Page IV, J(C)-7. Several general questions concerning LA-5483, used here as part of the EIS should be answered before its applicability to human risk evaluation is accepted by the AEC.

Can "oat cell" carcinomas be produced in animals by irradiation with any radiation type or is it strictly a human cancer?

Have animals exposed to radiation, particularly external radiation, been adequately examined to insure that reported lung tumors are primaries, not secondaries to Harderian gland tumors (rodents) or mammary tumors (dogs and rodents)?

51. Page IV, J(C)-9, 4. The "animal data" comment concerning use of animal data for comparative pathology page IV, J(B)-11 also applies here. In addition, the admonitions of Bair (W.J. Bair, Inhalation of Radionuclides and Carcinogenesis, pp. 77-101 in Inhalation Carcinogenesis, AEC Symposium Series #18) might also be considered:

> The experimental animal studies have clearly demonstrated the carcinogenicity of radionuclides deposited in the lung. Though we are tempted to extrapolate these results to man, at least qualitatively, we are well advised to exercise caution, because radon and radon decay products have not induced lung cancer in experimental animals, yet are strongly suspect as being the cause of lung cancer in miners. Extrapolation of experimental animal data to man on a quantitative basis can be even more misleading because a common denominator for comparing radiation doses to lung tissue has not been identified. Thus, it is difficult to relate the doses estimated for the bronchial tissues of the uranium miners to the doses calculated for the experimental animals. It would seem urgent that the next generation of experiments be directed toward this problem. Factors which need evaluation are the relative susceptibilities of human and experimental animal tissues to radiation-induced cancer, the relative latent periods for the induction of cancer in man and other species, possible species differences in the rates of clearance and translocation of inhaled radionuclides, and a number of other factors which pertain to the still unknown mechanisms of tumor induction. A serious obstacle to evaluating results of animal experiments with inhaled radionuclides and extrapolating them to man is the difficulty in identifying the effective biological target tissue in the lung and measuring the radiation dose to that tissue.

That the state of the art has not advanced much beyond that point, should be made clear to the readers of the EIS.

52. Page IV, J(C)-10, third paragraph. Implying that plutonium deposition in lymph nodes only rarely induces tumors in lymphatic tissue is probably erroneous and/or specious. Bair et al (W. J. Bair, J. E. Ballou, J. F. Park and C. L. Sanders, Plutonium in Soft Tissues with Emphasis on the Respiratory Tract, pp 502-568 in Handbook of Experimental Pharmacology XXXVI. Uranium - Plutonium - Transplutonic Elements, Springer-Verlog, New York 1973) mention some reported malignant lymphomas and also the possibility that plutonium deposited in lymph nodes may cause thoracic sarcomas by irradiating local endothelial and mesothelial tissues.

Of the malignant lymphomas, two observed in dogs and several in cats after inhalation of plutonium were reported "..., but the incidence was probably not greater than in controls." In the two cases reported for dogs the pattern of lymph nodes involved was not readily relatable to the nodes with greatest plutonium deposition nor to natural lymph drainage patterns since one involved mandibular and mesenteric nodes the other all nodes and viscera (E. B. Howard, The Pathology of Experimental Lung Tumors in Beagle Dogs, pp 147-160 in Morphology of Experimental Respiratory Carcinogenesis, AEC Symposium Series #21, 1970). One lymphoma was reported in a dog after subcutaneous injection of plutonium oxide. However, in this case also the distribution of lymph nodes involved suggests the retrograde movement of plutonium in the lymphatic system would be needed. Since only the prescapular lymph node (not involved in the malignant lymphoma) appears to have been radioassayed it is difficult to tell if there was any plutonium in other nodes (J. L. Lebel, E. H. Bull, L. J. Johnson and R. L. Watters, Lymphosaicoma Associated with Nodal Concentration of Plutonium in Dogs: A Preliminary Report, Amer J. Vet. Res 31: 1513-1516, 1970). In studies done by Bistline (R. W. Bistline, Translocation Dynamics of 239-Plutonium, C00-1787-20, 1973) there is no indication of transfer of Pu from regional lymph nodes to contralateral nodes or visceral nodes. Further, Dagle (G. E. Dagle, Lymph Node Clearance of Plutonium from Subcutaneous Wounds in Beagles, C00-1787-18, 1973) reporting on pathology of lymph nodes containing plutonium states:

"The eventual sequesting of plutonium in the scar tissue of lymph nodes probably alleviates the potential of the alpha radiation damaging the host. The alpha particles only penetrate soft tissues up to 50 and the presence for rather hypocellular scar tissue of this distance around the plutonium means that the alpha particles have ceased to come in contact with parenchymal cells. If parenchymal cells are no longer damaged directly by irradiation, there may be less chance of mutagenic or other action causing tumor induction.

The final lymphoma reported was seen in a pig following intradermal injection of plutonium. This lymphomas is also probably nonrelevant since the doses administered were split to between 18 and 152 separate injection sites (J. W. Cable, V. G. Horstman, W. J. Clarke and L. K. Bustad, Effects of Intradermal Injections of Plutonium in Swine, Health Physics 8:629-634, 1962) so that many regional lymph nodes would be involved and irradiated. However, the lymphosarcoma developed in a visceral node, the hepatic lymph node. Thus, there is no causality demonstrated in any lymphatic tumors associated with Pu. The observation of lymphoproliferative diseases

in occasional animals is not unexpected and should be placed in perspective if mentioned.

53. Page IV,J(C)-15. Inhalation studies in beagles are poor sources of data since the doses administered were so large that radiation fibrosis and edema were induced. These processes isolated that inhaled material and destroyed normal physiology and histology. As Howard reported (E. B. Howard, The Morphology of Experimental Lung Tumors in Beagle Dogs pp 147-160 in Morphology of Experimental Respiratory Carcinogenesis, AEC Symposium Series #21, 1970) in the beagles the following relationships were observed, an alveolar deposition of 0.1 μCi/g or more, associated with acute death, 1-12 months post exposure; 0.05 /g with subacute death, 1-5 years post exposure and only at doses of about 0.01 μCi/g is the delayed effect response observed. Bair etal (W. J. Bair, J. E. Ballou, J. F. Park and C. L. Sanders, Chapter 11 Plutonium in the Soft Tissues with Emphasis on the Respiratory Tract, pp 503-568 in Handbook of Experimental Pharmacology XXXVI, Uranium•Plutonium•Transplutonic Elements, Springer-Verlag, New York, 1973) report that 39% of the beagles died of lung neoplasia and 100% of those surviving more than 1600 days past exposure died of pulmonary neoplasia. There were two mortality curves extractable from the data, one for fibrosis (5-900 ηCi/g deposited), the other for neoplasia (3-45 ηCi/g deposited). The exposure levels for most of the beagles was too high to allow delayed effects-neoplasia-to develop Results are not at all representative of what might be expected at lower exposure levels. Current experiments using lower exposure levels may be more pertinent to expected population exposures. These facts should be made clear to the reader.

54. Page IV, J(C)-16, second paragraph. The assumption of relationship of lymphopenia, lymph node pathology, reduced immunocompetancy and pathogenesis of plutonium-induced lung tumors should be explained and justified.

55. Ibid, fourth paragraph. It is premature to state the gonads are not critical organs. Effects of plutonium on gonads have not been examined for below the level of acute effects. Studies on pre- and post-natal wastage, future reproductive capacity, teratogenesis or other congential effects on progeny have not been tested for. Ovcharenka (E. P. Ovcharenko, An Experimental Evaluation of the Effects of Transuranic Elements on Reproductive Ability, Health Physics 22:641, 1972) reported decreased viability, delayed physical development, disturbance of blood formation, change of radiosensitivity and depression of sex function in offspring of animals receiving ^{239}Pu or ^{241}Am and increased uterine death in

offspring of males, receiving the same isotopes, mated to normal females. These results imply direct effects on the gonads and/or the reproductive tract. The data on biological distribution and estimated dose provided by Fish etal (B. R. Fish, G. W. Keilholtz, W. S. Snyder and S. D. Swisher, Calculation of Doses of Accidentally Released Plutonium from an LMFBR, ORNL-NSIC-74, 1974) suggest that the impact of Pu on the ovaries may not be negligible. The need for further examination of the question should be considered.

56. Ibid, fifth paragraph. The experiments alluded to which are still in progress, while not showing increased mortality in neonates as stated here, have demonstrated an age-related difference in development of tumors and other age differences in response to plutonium insult which is not mentioned. (Seattle 1974, IRRS meeting.) Perhaps the EIS could be more inclusive in describing these studies.