UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D. C. 20555

November 18, 1976

Mr. Lee V. Gossick
Executive Director for Operations
U. S. Nuclear Regulatory Commission
Washington, DC 20555

SUBJECT: UNRESOLVED ISSUES ON THE DRAFT GENERIC LIQUID PATHWAY STUDY FOR THE FLOATING NUCLEAR PLANT

Dear Mr. Gossick:

The ACRS Subcommittee on the Floating Nuclear Plant met in Los Angeles, California, on October 27-28, 1976, to compare the potential consequences of a large accident (core melt) in a floating nuclear plant and in a land-based plant. Highlights of this meeting are provided in Attachment 1. The Subcommittee, based on the information provided at that meeting, was unable to reach a conclusion regarding comparative consequences, but indicated that the Committee would discuss the existing Draft Generic Liquid Pathway Study in executive session at the November 11-13, 1976 Committee meeting, and inform the NRC Staff of the future plans for the Committee's review of this study.

The Committee has received several sets of comments from its consultants who attended the October 27-28, 1976 Subcommittee meeting. The comments provided by the consultants provide a description of most of the major items which were discussed but not adequately resolved to the satisfaction of the Subcommittee.

The Committee has requested that the items listed in the consultants' comments, as provided in Attachment 2, be resolved in a written report prior to any further review by the ACRS. In addition, the transcripts for the October 27-28, 1976 Floating Nuclear Plant Subcommittee meeting and for the November 10, 1976 Reactor Safety Study Working Group meeting should be reviewed and those additional unresolved questions concerning the comparative analysis of accidents in a floating nuclear plant and in a land-based plant should be addressed. This report should be developed to validate the NRC Staff's conclusions with respect to the relative consequences from a core melt accident in a floating nuclear plant and a land-based plant.

The ACRS Floating Nuclear Plant Subcommittee will meet again to discuss the Draft Generic Liquid Pathway Study following resolution of the items mentioned as well as of the comments received from other agencies and/or individuals asked to review the Draft Study.

Sincerely yours,

Dade W. Moeller

Dade W. Moeller
Chairman

Attachments:
1. Highlights of the 10/27-28/76 FNP Subcommittee Meeting
2. Comments from ACRS Consultants on the Draft Generic Liquid Pathway Study for the FNP

ATTACHMENT 1

HIGHLIGHTS OF THE OCTOBER 27-28, 1976
FLOATING NUCLEAR PLANT SUBCOMMITTEE MEETING

1. This was the 9th Subcommittee Meeting on the Floating Nuclear Plant. The purpose of the meeting was to review the following three outstanding items listed in the June 7, 1976 ACRS Interim Report on the FNP.

   - Liquid Pathway Study
   - ECCS Analysis With Upper Head Injection
   - Shipping Accident Probability

   The Radiological Safety Hearings before the ASLB began on June 15, 1976 but cannot be concluded until the ACRS completes its review of the FNP and issues a final report.

2. The NRC Staff and Offshore Power Systems have concluded that the consequences associated with the release of a large radioactive source by a floating nuclear plant are generally comparable to the estimated consequences for a land-based plant and that there is no need to incorporate any design features dealing with core melt.

3. The Subcommittee found the Liquid Pathway Study inadequate in certain areas and was unable to conclude, based on the information provided, that a core melt in the FNP would not provide worse consequences than in a land-based plant. Some of the areas requiring further clarification before a decision could be reached included:

   - Assumptions used concerning the size of core material released during a meltdown (e.g., 20% particulate with mean particle size of 1000 microns) are questionable.
   - Cutting off the leaching of core materials after 2 years following a postulated core melt is questionable.
   - The assumption that particulates stay inside the breakwater following a postulated core melt is questionable.
   - The possibility and effects of steam explosions have not been investigated adequately.
   - Would a "last ditch containment venting system" to vent the containment underwater be worthwhile to reduce airborne releases in case of a core melt accident?
   - Should Strontium and other forms of radioactivity be assumed to travel at the same speed?

- Acute doses to individuals should be addressed.

- The FNP fish consumption model cutoff at 50 miles with core leaching cutoff at 2 years does not appear justifiable.

- It is not clear that the same set of ground rules were used in applying conservatisms to assumptions used for both the FNP and the land-based plant.

4. The Subcommittee was in general agreement that accidents through Class 8 were no worse for the FNP than for a LBP.

5. The FNP ECCS analysis, using a NRC approved evaluation model, has not yet been completed. OPS has committed to developing an ECCS model in accordance with Appendix K to 10 CFR 50 which will be acceptable to the NRC Staff. In addition, OPS has agreed to do whatever is necessary to ensure that the floating nuclear plant design meets all of the requirements of 10 CFR 50.46. OPS informed the Subcommittee that based on a preliminary evaluation model, not yet approved by the NRC Staff, it appears that the proposed floating nuclear plant will meet the criteria in 10 CFR 50.46 without any plant changes. The Subcommittee expressed its concern that peaking factors which the ACRS sees at the construction review are frequently lowered by the NRC Staff after the ACRS review is complete.

6. The NRC Staff and Applicant have not altered their approach on shipping accident probability since the issuance of the June 7, 1976 ACRS Report. The Subcommittee expressed its concern that the sum of probabilities for all types of events may be more than 1×10^{-6}. The NRC Staff members, present at the meeting, did not know if a list of all possible accidents, which are included in the 1×10^{-6} total probability, is in existence.

ATTACHMENT 2

A Summary of Certain Aspects of the
Subcommittee Review of the Floating Nuclear Power Plant
October 27 - 28, 1976

The conclusion reached by the applicant and the staff was that the consequences of a core melt would be comparable for a floating nuclear power plant (FNP) and a land based plant (LBP). The conclusion was based on a study, reported in NUREG-0140, where

a) arguments are given to justify that a prompt release (sump water) will not occur in a FNP,

b) models are presented for the source used in both FNP and LBP releases by leaching

c) possible consequences of a steam explosion below the barge are not given, and

d) it is inferred that the airborne path dominates.

The conclusion reached, the justification for the conclusion, the models used in assessing consequences and arguments for believing the results, at least for non-biological aspects, are very similar to those presented at the subcommittee review of FNP held on 4 February 1975. This summary will only address the comparative consequences of the core-melt accident.

A prompt release of radioactivity from a FNP during a core-melt-down results if the sump water is ejected into the waters surrounding the barge. It is argued that the containment will fail due to overpressure before the molten core penetrates the bottom of the barge. Under such circumstances, it is argued, no driving force exists to push the sump water out of the barge. Several reasons why this is the case are given on page A-13 of NUREG-0140. In order that one can be assured that the containment fails due to overpressure before melt through occurs, knowledge of the melting process must be available. The question of how well melt-through time and time to overpressure failure is known was raised to assess the confidence in the presented results and no answer was given. It seems appropriate to assume that a prompt release will occur unless it can be demonstrated that the melt through process is slow enough. The experimental program at SANDIA, funded by WRSR, should help in understanding melt-through of the concrete in the barge. Melt-through of the steel (vessel, core support etc.) is under investigation for CRBR safety studies. For a comparative study to be made, such efforts should be considered in assessing consequences of both FNP and LBP.

The source terms used for both the FNP and the LBP are somewhat arbitrary. For the FNP it is assumed that the molten fuel is 20% fragmented to 1000 micron particles with the remaining 80% being a solid disk. The area for leaching is the sum of the areas of the fragments plus ten times (to account for cracking) the area of the disk. The percentage assumed to be fragmented is stated to be "a realistic amount. Cold water and hot ceramic like materials usually lead to fine fragmentation. Most experimental efforts have involved hot metals into water or molten UO_2 into sodium. The resulting interactions have all resulted in fragmentation of a similar nature. A range of sizes results with the largest fragments being about 1000 microns in diameter with a majority of the particles being much smaller. Recent water coolant experiments at UCLA using molten glass to simulate UO_2 have yielded size distributions similar to those obtained for molten UO_2-Sodium experiments. The applicant bases his source model on a single experiment (Gibby, BNWL 362, Jan 1967) where 1 to 10 gms of molten UO_2 were dropped into an undefined amount of water. The applicant did not know whether or not the water was sub-cooled and what fragmentation was associated with what water temperature. The concrete on the bottom of the barge will generate gases that will bubble through the molten UO_2 during the melt-through process. This could lead to enhancement of the surface area of any large masses of UO_2 and forms eutectics with lower melting temperatures, explosive interactions and fine fragmentation could become more likely. As can be seen from the above discussion, the applicant has not presented a convincing argument for his choice of a source for the FNP and there is reason to believe that the source could be significantly larger than that used in the comparative study.

The source used in the LBP assessment was also somewhat arbitrary. It is assumed that the debris melts into the ground and mixes with the melted material to yield a cylinder 21 meters in diameter and 16 meters high. The area is assumed to be ten times that of the cylinder to account for cracking. It is then assumed that the water will not contact the cylinder for one year because it is too hot. First, it is not known how a large molten mass will penetrate into a less dense substrate. There is some indication that the rate of spreading could be several times the rate of downward penetration. This will lead to a greater surface area and more efficient cooling. The assumption of complete mixing is not fully established as yet. Second, the assumption of no water contact for one year is only valid if the heat transfer is very poor. It has not been possible to obtain a description of the computations that lead to the one year hold up in leaching. It can only be assumed that the mode of heat transfer was assumed to be conduction. If natural convection and phase change were to be included in the analysis, it is easy to imagine a several fold increase in the heat transfer and a corresponding decrease in the hold-up time (time until leaching starts). More study will be necessary if one wants to be sure that a realistic model for the LBP is being used.

During the two day meeting, steam explosions were mentioned several times. No assessment of the impact of a steam explosion on the integrity of the barge was given. For a LBP, it can be argued that, at least for non-ice-condenser containment, the water is near saturation and steam explosions will probably not change the course of events very much. For an ice condenser containment, it is possible for cold water to come in contact with molten UO_2 and the chances of a damaging steam explosion are much greater. In particular, if cold water can be trapped in the sump under the molten UO_2. The FNP has an added problem in that it has an ice condenser containment as well as a large amount of cold water below the barge. If a steam explosion occurs before penetration, earlier penetration may result and the sump water may be blown out of the barge. When melt-through occurs, a large amount of molten fuel (hundreds of tons) will come in contact with the cold ocean water. How the melt-through occurs will be very important. If a small breach occurs and the molten material pours into the water as a jet, a steam explosion may not occur. If, on the other hand, a large breach occurs and water is trapped under the molten UO_2, then a large steam explosion may occur and as a result significant damage to the barge may result. A steam explosion below the barge could cause a significant increase in the prompt release as well as enhance the fragmentation process.

The radiation transport models were relatively simple but probably adequate for a comparative study. The ocean study does, however, seem to lack any consideration of surface currents such as might be caused by winds and tides and decreased diffusion as might be caused by strong stable stratification. If a large prompt release were to occur, it is conceivable that the contaminated water or "patch" exiting from the breakwater could reach shore with a dilution on the order of 100 to one and a transit time on the order of one day. The resulting contamination of the shore line due to these speculations deserve some consideration. That such phenomena occur is evidenced by occasional beach contamination with sewage from outfalls that are supposedly placed to minimize contamination.

The comparison of core-melt consequences for a FNP with a LBP were further weakend by what appeared to be use of different rules for the two types of plants. No interdiction of the consequences was assumed for the FNP.

To summarize, the weakest parts of the comparative study of consequences of a core-melt are

1. the justification for deciding whether or not a prompt release will occur in an FNP,
2. the source model for both FNP and LBP being somewhat arbitrary and weakly based,

3. the assumption that a steam explosion will not occur below the barge,
4. the consideration of early shore direction drift of the "patch" and
5. the assumption of interdiction for a FNP and no interdiction for a LBP

As a result, aside from biological considerations, the conclusions presented in NUREG-0140 must be viewed with caution.

COMMENTS ON THE FLOATING NUCLEAR PLANT

October 29, 1976

I was somewhat disappointed in the comparative study of the Floating Nuclear Plant, FNP and the Land Based Plant, LBP as judged by reports provided by the Nuclear Regulatory Commission, NRC, and by the presentations before the ACRS Subcommittee Meetings in Los Angeles, California, October 27 and 28, 1976 for reasons, some of which are as follows:

1. Except for one uncertainty, I am convinced that the FNP generically is as safe as the LBP and in some cases can be made safer than some of the LBP's such as St. Lucie Nos. 1 and 2. The above referred to reports on generic comparisons indicate that the radiation risks associated with airborne radioactive contamination are expected to exceed those for water borne radioactive contamination both for the FNP and the LBP. It is concluded also that the risks of airborne radioactive contamination are comparable for the FNP and the LBP such that the major comparison and risk evaluations would be based on a comparison of the water borne radioactive contamination risks associated with the two systems. I believe this conclusion is warranted on a generic comparison but not when the comparison is made with specific LBP's such as the island sited reactors, St. Lucie I and II. In this case I consider the risks from airborne radioactive contamination at St. Lucie Nos. 1 and 2 are far, far greater than any conceived risks associated with FNP at the proposed New Jersey site.

In the above I expressed one specific uncertainty or misgiving relative to the conclusion that generically the FNP is safer than the LBP; viz what is the probability of and what are the risks of a steam explosion being generated under the floating barge if and when the large mass of molten fuel, iron, concrete, etc. comes into contact with the water underneath the barge and entraps a large pocket of steam at very high temperature? This seems to me to be the 64-dollar question and until I know what happens to the barge under these circumstances and to the entrainment of small particles of the reactor core in the ensuing mushroom clouds, I would be reluctant to express judgement on the relative accident risks of the FNP and the LBP.

2. Some of the questions raised at previous meetings of the subcommittee have not been answered to my complete satisfaction. For example, my own measurements following test Baker at Bekini indicated a very high selective retention of some of the beta-emitting radionuclides on some of the materials on the atoll

beach (e.g. tars, oxides, oils, paints, etc.) such that in these areas of the beach the β-dose rate was 5 to 600 times the average γ-dose rate. Certainly following an accident with the FNP there would be the potential for beach contamination with tar, oils, oxides, etc. and I would like to see some estimates of the dose (rem) to individuals (rather than population doses of man. rem) who sun bathe in these beach areas. Admittedly, remedial measures might be taken in these high risk areas but for better comparative data (viz FNP vs. LBP areas) I would like to see some of the dose estimates to individual sun bathers.

3. In view of the many months since the last meeting we have had on the FNP it seems to me some knowledgeable person could have spent two days reading over report NUREG-0140 very carefully before it was issued as a draft report. Because of the errors in grammar, formulation of equations, nonenclature, etc., one may justifyably question whether or not all the scientific and engineering questions have been given expert review and evaluation. I have seven Ph. D. students doing their research under me at Georgia Tech and if any one of them turned in a thesis so poorly developed, I probably would discourage him from going on to the defense of his thesis and completion of the requirements for the Ph. D. degree.

4. I was very concerned with the weakness of the basis on which the assumption was made of a mean mass diameter of 1000μ of the particles emitted following a core melt down and penetration of tons of UO_2 and contaminants into the cold water under the barge. Should the mean mass diameter be 10μ instead of 1000μ and should there be a steam explosion, it seems to me there might be a mushroom steam cloud produced that would transfer a large fraction of the reactor core to the mainland. Such a series of events would cause the FNP accident from core melt to be orders of magnitude more severe than similar accident with a LBP.

5. The comparative evaluation only treated averages and stated it did not consider the possible exposure to an individual or group of individuals who through a combination of possible site specific features, personal habits and discrete utilization of an unusual exposure pathway coincident with the accident might be exposed to extraordinary high pathway concentrations. Unless I could know the size of these excluded populations in this comparative analysis, I would be forced to conclude the principal population groups that should have been evaluated in this study were excluded from this comparative analysis. For example they sometime exclude the Welsh people south of Windscale who eat sea-weed that is contaminated with radionuclides Windscale discharges into the Irish Sea because this is a population of only a few hundred. In short on this comparative analysis have they for example excluded from the comparison those individuals who sun bathe on the beaches before remedial measures were taken

and as a consequence receive lethal radiation doses?

6. I am a bit puzzeled at the conclusions of the radionuclides that contribute the most significant doses to the population. In our tests of nuclear weapons in the South Pacific it was not the ^{106}Ru and ^{90}Sr that caused the greatest concern but the ^{65}Zn and the uptake in the tuna fish. I would suspect that in case of a core melt down the principal problems would evolve from $^{58,60}Co$, ^{65}Zn, ^{59}Fe, etc. instead of those radionuclides considered in the comparative analysis of the FNP and the LBP.

7. I am surprised to note in this comparative study that ^{106}Ru travels as slowly as $^{90}Sr+^{90}Y$ through the soil. In our open pit studies at ORNL the ruthinates and nitrates traveled like lightening in comparison with ^{90}Sr.

8. It is a bit of a letdown to be informed that crustations (shellfish, etc) were not considered in this comparative study. Since this is primarily a seawater problem, this might seriously bias the comparative study of FNP vs LBP's.

In conclusion, I would like to emphasize that on a case-by-case basis, I believe the FNP can be shown in certain cases to be safer than the LBP but in the generacic sense I do not believe the case is proven adequately.

The stated objective of the liquid pathway study was "...to determine whether the relative risks associated with accidental releases to the liquid pathway from water-based plants are dif ferent and significantly larger than those from land-based plants (LBP's)." The study considered accidents in classes 3 to 8 and also an accident beyond the design base which postulates containment melt-through. On the basis of the Draft Liquid Pathway Generic Study, the staff concluded that "...the overall risks associated with a floating nuclear plant are comparable to the risks associated with land-based plants" (page v of NUREG-0140). This conclusion was based on the statement that, "Consequences via the liquid pathways of the various postulated accidents at a floating nuclear plant are expected to be comparable to or less than those at a land-based plant." The "consequences" discussed in NUREG-0140 are dose commitments to populations and to maximum individuals and radiation-caused effects on aquatic life.

The NRC staff made the dose calculations for the land based sites and the applicant made the calculations for the floating plants. The results of the calculations for the class 3 to 8 accidents (but not the core-melt accident) are tabulated in Appendix F in the form of man-rem for populations and rem for maximum individuals. The tables show the dose estimate for several critical organs (total body, bone, thyroid, and GI-LLI) from each of four exposure pathways (drinking water, fish consumption, shoreline, and swimming) The man-rem calculations are used as a basis for histograms that appear in the main body of the report as Figures 7.1.1 through 7.1.4.

The reasonableness of the conclusions drawn from Figures 7.1.1-7.1.4 (and the basic data presented in Appendix F) is highly dependent upon assumptions about radionuclide source terms and their dispersion and about population density, the habits of people, and fish production and use. It is in this area of assumptions that NUREG-0140 is especially obscure. It is evident that generic assumptions were used to define the demographic and fish-eating habits of the exposed populations with a minimum of fine tuning to make them more characteristic of real populations that would actually exist in the vicinity of any specific site.

Apparently no dose mitigating actions were invoked for the class 3 through 8 accident evaluations but some dose restrictions were used in the case of the core-melt accident. These mitigating actions included fixation of the source of contamination so that it did not continue to contaminate the ocean for an extended period of time (years) and exclusion of individual exposures greater than a selected level (10 rem). For the floating plants, dose rates less than natural background (from fish harvested beyond 80 km of the accident site) were not included in the man-rem totals. Some of the assumptions are discussed in the document at some length in Sections 3, 4, and 6, and with much effort the reviewer might be able to reconstruct how they were used by the staff for the credible accident scenarios of special interest. However, because of the way NUREG-0140 is organized and the way that the "ground rules" for dose calculation are presented, it is not all clear that the "consequences" (dose estimates) for land based plants and floating plants are comparable.

A much more convincing presentation for a comparison of credible (design base) accidents would be to select a surrogate location (say an estuary or open coast) with a set of hypothetical but "typical" parameters (demographic, fisheries, shellfisheries, shoreline use, etc.) and to describe the scenarios for comparable accidents (such as Event C — loss-of-coolant) for a land based plant and a floating plant placed at that surrogate location. The description should clearly indicate assumed differences in source terms, differences in dispersion (and the choice of models to show this), differences in exposure to individuals and populations who are swimming or using the shoreline (same people for both kinds of plants), differences in kinds and levels of contamination to local fish and shellfish, differences in far-field contamination of fish, and differences in the dose to individuals and populations who eat the fish and shellfish. For each scenario any interdiction that was invoked, such as blocking of the source term after two years, should be clearly stated.

Although the class 3 to 8 accident evaluations provide much useful information (particularly in regard to the source and persistence of the radionuclides of greatest radiological significance, the critical pathways of exposure, and the occupations and habits of people who are most vulnerable), it is the core-melt accident which is of paramount significance in respect to the stated objective of the liquid pathway study of determining the relative risks of land-based vs. water-based plants. Table 7.2.3 presents population dose estimates (man-rem) for floating plants located on estuaries and the ocean in comparison with land-based plants. For this important comparison, the assumptions about pathways of exposure, population distributions, habits of people and the invoking of interdiction are even more obscure than for the lesser accident cases. The assumptions that are described seem to point up a lack of consistent rationale between the land-based plants and the floating plants. Some of the statements used in Section 7 that are confusing to the reader (especially in relation to comparability of LBP's vs. FNP's) are:

<u>Page 7-6</u> - "The exposure period considered in the analysis [LPP's] was the 100-year period after the accident."

<u>Page 7-9</u> - "These estimates [FNP's] are based on a two-year leach coupled with a two-year environmental evaluation with no pathway interdiction."

Page 7-12 - "Assuming a 10 rem interdiction..., the consequences of a large prompt release from all land-based and floating plant sites evaluated compared within a factor of 50,..."

Page 7-10 - "Detailed modeling of the shellfish component of the aquatic food pathway was not possible..."

Page 7-11 - "Thus, for estuarine-coastal waters, the shellfish pathway is estimated to be a factor of two higher than the finfish pathway."

Some additional assumptions used for the FNP that do not seem to appear in NUREG-0140 are:

OPS Document TR 01A89

Page 5-1 - "The dose calculated for the fish ingestion pathway represent the 50-year life-time dose commitment which results from consumption of contaminated fish for two years immediately following a postulated accident,..."

Page 5-5 - "The population size was determined by first determining the fish harvested within an 80 km radius of the FNP site. ...the harvest would supply a population of 9 million people which was the population used for these calculations."

Page 5-5 - "The 80 km limit was selected as a cutoff for dose calculations primarily for hydrological reasons. ...further extrapolation taking into account the model's conservatism would only yield man-rem values comparable to those from natural background."*

Page 5-6 - [Relative to direct exposure to people on the beach] "The dose estimates assume that access to beaches is restricted within 48 hours of the accident and that no exposure occurs after this time."

NUREG-0140 does not present specific data on the relative importance of various exposure pathways for the core-melt accident, but it seems clear that nearly all of the population dose (man-rem) is postulated to result from the drinking of water from public wells used by a large population located about 50,000 feet "down aquifer" from the offending core. Additional details about the volume of water flowing in the aquifer and the numbers of people that can practically be served by such a source are needed before the reasonableness of the assumption (and thus the man-rem estimates) can be assessed. Further, Figure 7.2.1 indicates that

*Presumably this would be on the order of about 100 mrem per year per person.

^{106}Ru does not travel through the ground any faster than ^{90}Sr. In view of the practical experience with neutral and anionic ^{106}Ru in the ground water beneath the Hanford reservation, this postulation should be reevaluated.

As in the case of the lesser accidents, much of the uncertainty and confusion created in the mind of the reviewer about the comparability of the dose evaluations for the LBP's vs. the FNP's could be cleared up if accident scenarios for similar sites were postulated and adequately described and if assurance was provided that the same "ground rules" were used in relation to interdiction and to the size and locations of the exposed populations. Further, it would be most helpful if the data were presented not only for populations (man-rem) but also for individuals. Not only should the major exposure pathways be described but also the time lines involved should be given so that the reviewer has some feeling for the practicality and time available for interdiction.

Another significant feature that is described in NUREG-0140 but not adequately developed is the relative contribution to dose of the sump water (prompt releases) as compared with that from the molten core (extended leaching). Adjustment of the source terms to ccommodate much faster leaching from finer particles, coupled with short-term and practical interdiction to minimize dose from the prompt source might reverse the relative significance of these pathways.

NUREG-0140 includes an extensive discussion about ecological consequences (Section 5) and potential effects on biota (Section 7.3). Virtually all of this discussion is in the form of background information and no estimates of dose are provided. Without the dose estimates, the reader has no basis for judging the reasonableness of the conclusion that the "...consequences are expected to be small..." To be of any real value, this section should postulate the kinds and extent of impacts based upon hypothetical (but realistic) assumptions of the marine organisms that will be subjected to estimated levels of radioactive contamination. The background information presented is only useful if it is used to justify the conclusions as to the nature, magnitude, and duration of the postulated impact.

November 3, 1976

Mr. G. R. Quittschreiber
Senior Staff Engineer
U.S. Nuclear Regulatory Commission
Advisory Committee on Reactor Safeguards
Washington, D. C. 20555

FLOATING NUCLEAR PLANT SUBCOMMITTEE MEETING, LOS ANGELES, CALIFORNIA, OCTOBER 27-28, 1976

Dear Mr. Quittschreiber:

At the subject meeting, Chairman Lawroski asked that the consultants submit a brief review of their findings to you.

The Chairman will recall that I recommended that, in the future, when the amount of prepared material is overwhelming, consultants be asked to concentrate on specific sections. I concede that my impressions of the FNP issues may be defective, in part because of incomplete assimilation of the copious material provided. My comments will be restricted to a few salient features affecting the radiation protection and environmental aspects.

The Draft Liquid Pathway Generic Study (NUREG-0140) is an attempt to answer earlier questions of the subcommittee concerning possibly intolerable consequences of major accidents to a floating nuclear power station. The report professes to show that the consequences are broadly similar to those for equivalent accidents to land-based stations. It fails in this objective for the following reasons:

1. The report is poorly prepared with frequent errors that tend to destroy confidence in those parts of the text which may be error free. Typical examples are:

    a. The only dose statement in the Executive Summary (p. iv) is utterly ridiculous. One only finds out how it got that way some 50 pages later on p 7-1, where it is discovered that two lines were omitted from page iv

    b. Table F-2 of Appendix F, under thyroid population dose, has an obvious error by a factor of 100. Also, any table that uses nomenclature such as 1.0E-5 in one line and $<10^{-5}$ in the next, is a technical monstrosity

2. The report generally is plausible, but one feels it is only one of a dozen equally plausible but vastly different scenarios. The Commission correctly states that a satisfactory answer could only be supported by an effort approximately equal to that involved in WASH-1400.

3. A principal doubt is whether the land-based sites and water-based sites have been treated equitably. I believe that they have not, although the impression could change with a much more detailed study. There are three factors in this:

   A. Use of Realistic Assumptions

   A point was made that this was a major objective. By contrast, assumptions in work done to date are said to be conservative. Much of the LBP case is copied from WASH-1400 which uses conservative assumptions. The FNP case is mostly new; it uses realistic (i.e., less conservative) assumptions. This biasses the comparison.

   B. Interdiction

   To suppress the consequences of the ultimate accidents, interdiction is introduced. Certain aspects of interdiction have been handled equitably for both cases. Others have not. As an example, calculation cut-off at two years is just as much a mitigation as posting a sign reading "Do not enter this lagoon;" it affects the two cases quite differently. In addition to the fairness issue, interdiction also tends to suppress the apparent range of consequences between major, severe, and ultimate cases.

   C. Mixed-up Use of NRC Data and OPS Data

   NUREG-0140 omits the most interesting part of the story because it seems to leave out the details of individual high exposures in the core-melt case. The authors appear to have overlooked the subcommittee concern that this was the key point. Apparently, such doses are said to be in the OPS work. Attempts to bring these numbers out in the meeting either met a phalanx of resistance, or we asked the wrong questions. Since the averaging of fish consumption, the total omission of shellfish data, and so on, made us feel that doses could be understated by an order of magnitude, we could not accept the NRC conclusion of parity.

Our concern is wholly with the extreme case. Lesser accidents seemed more likely to be comparable for LBP and FNP cases, or perhaps favorable to the FNP case.

As a practical suggestion, I would like to see NRC re-examine its bases to see if these potentials for bias are indeed real. Perhaps two parallel analyses with "equally realistic" assumptions for FNP and LBP cases would be helpful. One case would use no interdiction or mitigation, either obvious or occult. The other would use mitigation for both cases as early and completely as one would expect to use it in the real world, should one of these disasters befall.

Again, these studies would be for the core-melt accident only, and realistically should cover three cases, not two, i.e., dry land, wet land, and floating sites. Let me add, for the record, that I am not suggesting any deliberate biassing of the data. Rather, the circumstances of the study conspire to make accidental biassing probable.

4. Along with subcommittee colleagues much better versed in the engineering aspects, I cannot accept the model of the percentage of the core that would be fragmented, nor the particle size distribution of the fragments.

   My concern is that the solubility in the short term may be orders of magnitude higher than postulated. This could add a class of major sub-acute exposure to the acute and chronic classes. Such a change could vastly alter the biomedical outcome--in fact be the controlling injury factor.

5. The consultants are sympathetic toward those who have the difficult task of writing the ecology section. However, the present section is more simplistic than usual. I think it will raise more questions with environmental critics than it will resolve.

6. For equal man-rem detriment, the U. S. should be more concerned when a good share of the detriment falls on other than our own community. I consider it necessary to publish the assumed effects of fish consumption on foreign nationals.

7. If I understood the data correctly, WASH-1400, revised, postulates a core-melt frequency of 1 in 20,000 reactor years. NRC seeks an internal serious risk frequency of

not more than 1 in 10^6. If one is truly to follow the ALARA principle, is it not axiomatic that a core-catcher, or whatever it takes to minimize the consequences of a core-melt, should be required?