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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of	)	
	)	Docket Nos. 50-352-OL-2
Philadelphia Electric Company	)	50-353-OL-2
	)	
(Limerick Generating Station, Units 1 and 2)	)	Severe Accident Mitigation

MEMORANDUM OF LIMERICK ECOLOGY ACTION, INC.
PURSUANT TO PREHEARING CONFERENCE ORDER OF
ATOMIC SAFETY AND LICENSING BOARD OF JUNE 9, 1989

Intervenor Limerick Ecology Action, Inc. ("LEA") submits the following memorandum in support of its position on mitigation alternatives.

I. The Scope of the Third Circuit Remand

In its decision in Limerick Ecology Action, Inc. v. U.S. Nuclear Regulatory Commission, 869 F.2d 719 (3d Cir. 1989), the United States Court of Appeals for the Third Circuit granted the petition for review of LEA and remanded the case to the NRC for "consideration of SAMDAs in light of this opinion". 869 F.2d at 741. The Court further noted that the Atomic Safety and Licensing Appeal Board had concluded -- contrary to the ASLB's conclusion -- that LEA's contention DES-5 met the Commission's requirements for "basis and specificity":

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> The Appeal Board concluded that LEA's contentions met the basis and specificity requirement because they were based on the studies sponsored by the NRC...[.]

869 F.2d at 732.

Thus, the "basis and specificity" of DES-5 as drafted[1/] is not -- and cannot -- be at issue because of the Appeal Board decision, noted by the Court, that the regulatory requirement for admission of the contention was satisfied by LEA.[2/] Therefore, the issues to be litigated in this proceeding are those issues

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[1/] LEA's contention DES-5 states: "The environmental risk of accidents during operation of the Limerick facility as proposed for licensing is significant, and preventative and/or mitigative alternatives to the design, mode of operation, procedures, and/or number of reactors presently proposed must be considered for purposes of compliance with the National Environmental Policy Act of 1969 and with 10 CFR Secs. 51.20(b), 51.21, 51.23(c) and 51.26. None have been considered."

[2/] The Appeal Board expressly stated: "[T]he interim material available to the Licensing Board at the time of its ruling on contention DES-5 appears to have satisfied the threshold basis and specificity requirements for admission of the contention...". Philadelphia Electric Co. (Limerick Generating Station), ALAB-819, ___ NRC ___ (1985), slip op. at 6. The Board also held that "the Licensing Board thus erred in excluding contention DES-5 for the reason it stated -- i.e., the lack of basis and specificity". Id. at 7. Thus, the law of this case is that LEA contention DES-5 as drafted is a contention admitted in this proceeding and possessing the required basis and specificity. We do not interpret the order of the Commission of May 5, 1989 stating "on remand, litigation on this contention should be limited to those mitigation alternatives identified by the Appeal Board as being supported with the required basis and specificity" as permissibly undercutting the law of the case, or purporting to restrict the scope of the contention as admitted, but rather only noting that the remand litigation should be limited to the issues raised in the contention. Any other interpretation would be to suggest that the Commission unlawfully limited the scope of the contention in a manner contrary to the law of the case and the remand of the Third Circuit.

raised by contention DES-5 as drafted. As we discuss below, the alternatives set forth by LEA in the list of "primary candidates" for severe accident mitigation submitted to the parties and the ASLB at the June 3, 1989 prehearing conference[3/] and the more comprehensive list submitted to the parties subsequently[4/]are within the scope of the proceeding and must be litigated.

II. The Alternatives Identified In LEA's Lists Are Within The Scope of the Proceeding

LEA's two lists (the list submitted to the parties and the ASLB at the prehearing conference of June 6, 1989[5/] and the Supplemental List provided to the parties subsequently) set forth mitigation alternatives within the scope of the proceeding. The list submitted by PECO, while within the scope of the proceeding, cannot possibly be considered to be the <u>limit</u> of the scope of the proceeding. As Judge Harbour so aptly noted at the June 6, 1989 prehearing conference, the PECO list "at best are a <u>precis or selection</u> from the RDA report and LEA's supplemental this that and the other thing". Prehearing conference transcript, p.22. Even counsel for PECO, Mr. Wetterhahn (although his statements on the record were somewhat contradictory) admitted

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3/ This list is attached hereto as Attachment 1.

4/ This list is attached hereto as Attachment 2.

5/ Counsel for LEA made it clear at the prehearing conference that with respect to the LEA list submitted at the conference, "we do not consider this list to be in any way the scope of the litigable contention". Transcript, p.25; see also id., p.11.

that the PECO list was "not fixed in concrete, if you will, but they <u>are a starting point</u> in order to respond to the [NRC] staff questions". Transcript, p. 23.

It is clear from DES-5 that the contention as now admitted includes consideration of "preventative and/or mitigative alternatives to the design, mode of operation, procedures" for Limerick.6/ All of the alternatives identified in LEA's lists fall within the scope of the contention. Virtually all of them (with only very few exceptions) clearly constitute "design" "mitigation" alternatives which would reduce the consequences of a severe accident, by truncating the progression of accident sequences which would lead to core melt and containment failure, by preventing containment failure, or by reducing the source term release from a severe accident.7/ For these alternatives which are clearly "design" alternatives which "mitigate" severe

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6/ The scope of the contention also expressly included consideration of alternatives to the "number of reactors presently proposed". DES-5.

7/As we noted at the prehearing conference, the line between "prevention" and "mitigation" is not a bright one. These expressions are inherently ambiguous, because often a plant modification which is proposed to mitigate accident consequences also has the effect of reducing the frequency of certain types of accidents. For example, containment venting has been proposed as a means of averting early containment failure for BWRs such as Limerick, but it also has the effect of significantly reducing the frequency of accidents caused by loss of containment heat removal -- that is, accident <u>prevention</u>. The ambiguity of the distinction between accident "mitigation" and accident "prevention" was also noted by R&D Associates in NUREG/CR-4025, "Design and Feasibility of Accident Mitigation Systems for Light Water Reactors", August 1985, p.1-2 ("as with any such definition [of accident mitigation and prevention] ambiguous cases will appear".

accidents, there should be no question of the litigability of such alternatives.

III. LEA Identified Numerous Alternatives Beyond The "PECO List" To The Atomic Safety and Licensing Board Which Are Within The Scope Of This Proceeding

Although LEA was not required to by the Third Circuit remand, Commission regulation or rule of practice, for the purpose of assisting the parties and the Board to discern LEA's present position on the scope of the issues raised by its contention, LEA has submitted its "Supplemental List of Litigable Severe Accident Mitigation Alternatives for Litigation of Limerick Ecology Action, Inc. Contention On Severe Accident Mitigation Alternatives for the Limerick Nuclear Generating Station" ("LEA Supplemental List").[8/] That list identifies, _inter_

[8/] We particularly note the present procedural status of LEA's contention: admitted into the proceeding as drafted, but prior to any discovery whatsoever on the contention or the issues raised thereby. Ordinarily, once admitted, no further particularization of the contention beyond its terms is required until the parties have had an opportunity to conduct discovery on the contention. For example, the Commission's regulations and rules of practice in domestic licensing proceedings contemplate a prehearing conference to discuss "simplification, clarification, and specification of the issues" _after the completion of discovery_. See 10 C.F.R. 2.752(a)("a prehearing conference held under this section...shall be held within sixty (60) days _after_ discovery has been _completed_" (emphasis supplied). Thus, while the parties have made an effort to provide specifications of the issues through the lists of alternatives provided, it should be clear that until discovery is completed, no final "specification" of the issues or the alternatives to be examined is possible or should be expected. This is particularly true where, as here, the issues raised by the contention are far-reaching, complex, and are at the cutting edge of risk assessment and risk management.

alia, those alternatives and the supporting documents which were identified to the ASLB prior to the ASLB erroneous decision on the admissibility of the contention. See LEA Supplemental List, Attachment 2, pp.1 to 10. In fact, all of the alternatives identified up to the middle of page 8 of the LEA Supplemental List were specifically identified in filings with the ASLB and were part of the Joint Appendix filed with the U.S. Court of Appeals.[9/]

In addition, the filings with the ASLB, made part of the Joint Appendix, made specific reference to documents which further specified alternatives which were the subject of LEA's contention. Those documents were identified by title and NUREG number (if applicable). Those documents included, for example, NUREG-0850, "Preliminary Assessment of Core Melt Accidents at the Zion and Indian Point Nuclear Power Plants and Strategies for Mitigating Their Effects", NUREG/CR-1029, "Program Plan for the Investigation of Vent Filtered Containment Conceptual Designs for Light Water Reactors", and "State of the Art of Reactor Containment Systems, Dominant Failure Modes, and Mitigation Opportunities", R&D Associates, RDA-TR-127301-001, Final Report, January, 1984. Thus, it is clear that the mitigation

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We also note that the NRC Staff has not yet prepared the Supplemental or Amended draft or final Environmental Impact Statement addressing severe accident mitigation alternatives which LEA contends must be prepared to comply with NEPA and the remand of the Third Circuit Court of Appeals.

[9/] References to the Joint Appendix filed with the Third Circuit are designated as "J.A." in the right hand column of the LEA Supplemental List, with the applicable page numbers listed.

alternatives and strategies set forth therein were identified to the ASLB and are within the litigable scope of the contention.

IV. Alternatives Which Are Identified In Or Suggested By Documents Published After The Erroneous ASLB Rejection of LEA's Contention Are Within the Scope of the Contention Upon Remand

PECO intends to litigate the issue on remand on the basis of its most recent risk assessment, "Limerick Probabilistic Risk Assessment, Philadelphia Electric Company, Revision 5, November 1988."[10/] The introduction to this document states that "PECo has updated the quantitative and qualitative evaluation of accident initiators and the possible course of accidents following the initiators". Id., at p.1-1. This document is significantly different from the PRA and SARA previously provided to the parties in 1981-198' and requires a new analysis by LEA.

Also since the time that this issue was unlawfully rejected by the ASLB, as LEA noted at the prehearing conference, significant new information on accident analysis and mitigation has been developed. NRC Staff counsel Stephen Lewis expressed the situation well:

> It is correct that there has been a lot of additional documentation and studies undertaken by the staff regarding severe accident mitigation alternatives since the time that the

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10/ This three volume document was provided to intervenor LEA at the Limerick Generating Station at a plant tour in mid-June 1989, and LEA's experts are in the process of reviewing and evaluating the document at the present time.

> Appeal Board focused on this question and rendered its decision in ALAB-819. And to the extent that those documents bear upon and have relevant information regarding severe accident design mitigation alternatives...then we think that those documents are relevant.
>
> And we certainly would not want you to understand us to be asserting that after developed information is not relevant. We certainly would want any record that is developed in this case to be based upon the most current information that the staff has developed.

Prehearing conference transcript, p. 18.

Indeed, if a realistic examination of risk reduction measures is the goal of the litigation [11/] it makes no sense to examine the issue in the "snapshot" version of events, plant design, reactor technology, and phenomenological understanding as they existed in 1981-1984. Such a limitation would make this litigation a pointless academic exercise. For example, PECO has asserted that the Limerick facility design has been modified in the intervening time frame. Does PECO intend to restore the Limerick facility design to its pre-1985 status so that it can be the subject of litigation? Of course not. But neither should LEA be precluded from asserting the state of the art available information in support of risk reduction measures. Indeed, it is LEA's view that any such limitation which would prevent an examination of risk reduction alternatives based on the best available scientific information would violate NEPA, Commission

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[11/] It is certainly LEA's goal; such a goal is apparently inconsistent with PECo's objectives in this litigation.

regulations, Commission policy, and would be an abuse of discretion.

For all of these reasons, LEA also included in its Supplemental List references to alternatives identified in documents which were created <u>after</u> the ASLB unlawfully excluded the severe accident mitigation issue from the licensing proceeding. Those references appear on pages 11 and 12 of LEA's Supplemental List (Attachment 2), and include the most recent R&D Associates' reports on Mark II containment severe accident mitigation[12/] and recent Brookhaven National Laboratory severe accident mitigation analyses.[13/] None of these documents were available at the time that LEA submitted its severe accident mitigation contention or even at the time that the ASLB rejected the contention. Thus, the procedural posture of the contention (admitted into the proceeding by 1989 remand of the Third Circuit, but prior to any discovery) and fundamental fairness require that the information in such documents be available for use by all the parties to the proceeding for any purpose for which it is relevant.

[12/] See e.g., NUREG/CR-4243, "Value Impact Analysis for Evaluating Alternative Mitigation Systems", January 1988 and NUREG/CR-4244, "Strategies for Implementing A Mitigation Policy for Light Water Reactors", January 1988.

[13/]See, e.g., NUREG/CR-4920, "Assessment of Severe Accident Prevention and Mitigation Features: BWR Mark II Containment Design", July 1988.

V. Spent Fuel Pool Accident Risk Modifications Must Also Be Considered Within the Scope of The Proceeding On Remand

LEA's proposed alternative of spent fuel pool accident risk modifications[14/] stands on somewhat of a different footing than the other proposed mitigation alternatives. These proposed modifications are being proposed as severe accident mitigation alternatives based on very recent studies.[15/]

This "severe spent fuel pool accident risk" can be mitigated with the alternative proposed by LEA. The alternative proposed is a facility design change, and it mitigates the risk of a "severe accident" if viewed as a beyond-the-design-basis accident

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[14/] See Attachment 1, pp.5-6.

[15/] Relevant documents and studies include the following:

(1) EPRI NP-3365, "Review of Proposed Dry-Storage Concepts Using Probabilistic Risk Assessment", NUS Corporation, Final Report, February 1984;

(2) NUREG/CR-4982, "Severe Accidents in Spent Fuel Pools In Support of Generic Safety Issue 82", Brookhaven National Laboratory, July 1987;

(3) NUREG/CR-5176, "Seismic Failure and Cask Drop Analysis of the Spent Fuel Pools at Two Representative Nuclear Power Plants", Lawrence Livermore National Laboratory, January 1989;

(4) NUREG-1353, "Regulatory Analysis for the Resolution of Generic Issue 82, 'Beyond Design Basis Accidents in Spent Fuel Pools", U.S. Nuclear Regulatory Commission, February 1989;

(5) NUREG/CR-5281, "Value/Impact Analyses of Accident Preventive Mitigative Options for Spent Fuel Pools", Brookhaven National Laboratory, March 1989;

(6) Proposed Rule, "Storage of Spent Fuel in NRC-Approved Storage Casks at Nuclear Power Reactor Sites", U.S. Nuclear Regulatory Commission, 54 Fed. Reg. 19379-19387, May 5, 1989.

with the potential for large radiological releases with population exposures off-site exceeding those postulated in 10 CFR Part 100.

While we understand that this proposed alternative does not fall within the other more classic severe accident mitigation design alternatives, it nevertheless is faithful to the purpose of the contention: to mitigate severe accident risks involving core damage. The main difference between the more classic alternatives proposed by LEA and the spent fuel pool accident mitigation alternative is that the core fuel bundles which are subject to accident damage and subsequent radiological release are not within their usual operating configuration, but instead are stored in the fuel pool above the reactor vessel.

Indeed, the litigability of issues relating to self-sustaining zirconium spent fuel pool fires was only very recently acknowledged in Vermont Yankee Nuclear Power Corporation (Vermont Yankee Nuclear Power Station), LBP-89-6, 29 NRC 127 (1989) (granting reconsideration of its exclusion of the issue, based on Sierra Club v. U.S. Nuclear Regulatory Commission, ___ F.2d ____ (9th Cir. No.87-7481, November 30, 1988) which reversed an Appeal Board rejection of a severe spent fuel pool accident contention). Indeed, LEA expressly relies upon the study (the "Brookhaven Report, NUREG/CR-4982) discussed in the Sierra Club decision.

It is clear that sometime over the next decade, PECO will be required to expend significant sums to expand Limerick spent fuel storage capacity. Its choices are either to rerack the spent fuel pool or to utilize dry cask storage. If approximately the same sums will be required for either option, it surely makes sense for PECO to choose the option which eliminates the recognized severe spent fuel pool accident risk.

For all of these reasons, the proposed design alternative intended to mitigate a severe accident involving core fuel bundles in the Limerick spent fuel pool should be deemed within the scope of the proceeding.

VI. The False PECO "Design"/"Procedure" Dichotomy

At the prehearing conference on June 6, 1989, counsel for PECO presaged an argument we anticipate will be made to the Board in PECO's filing:

> [The alternatives] must be design alternatives. They must be physical additions to the plant which would mitigate this assumed core melt. As I heard them and as I look through the list provided by Mr. Elliott, some of the ones provided were certainly not design alternatives. They may change procedures...but those are not design alternatives within the scope of the remand.

Prehearing conference transcript, p.20.

But if PECO were to be taken literally, the Board could not consider the procedures necessary to implement the design changes being proposed for litigation, even those which PECO agrees are within the scope of the proceeding. For example, according to PECO's argument, the parties could litigate the design change of a separate dedicated pool heat removal system, but be unable to discuss or litigate the proper operational or procedural circumstances for its use. According to PECO, we can litigate a filter vent of the containment, but we cannot litigate the procedures to use the filter vent.[16/]

In short, the strict "design"/"procedure" dichotomy urged by PECO is senseless even in the limited litigation scope of this case which PECO posits. But it is also unjustifiable from both a legal and a practical technical perspective. It is legally unjustifiable, because the contention DES-5 as admitted into this proceeding expressly includes "procedures" as alternatives to be examined. While the primary focus of LEA's concerns was physical changes to the plant, the wording of the contention and the documents submitted to the ASLB made it clear that procedural alternatives were among the risk reduction measures which LEA contemplated to be within the scope of the proceeding. For example, as part of LEA's submissions to the ASLB (and made part of the Joint Appendix before the U.S. Court of Appeals) we excerpted portions of the study "State of the Art of Reactor Containment Systems, Dominant Failure Modes and Mitigation Opportunities", January 1984. At page 1-5 of the study[17/] R&D Associates expressly identified "operator action" as <u>part of</u> a "containment mitigation system", defined as a "cooperative

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16/Will PECO also argue that none of the design changes proposed are cost-effective, because none of them can be implemented without use of procedures which are beyond the scope of the contention?

17/ Joint Appendix, p. 237.

combination of devices, subsystems, and components". It stated that "operator action can be a part of such a system" (Id.), and that "operator action or modification of existing equipment can possibly perform as well as dedicated hardware in some cases and at lower cost". Id.[18/] Thus, as presented to the ASLB and to the Court of Appeals, operator action and procedures were clearly within the scope of the issues to be litigated.

This is no mere academic matter. The more recent PECO risk assessment is a significant departure from the risk analyses which were submitted by PECO in this proceeding prior to LEA's appeal to the U.S. Court of Appeals. That assessment may significantly change the cost-benefit of various risk reduction options that LEA had examined in the past.[19/] Thus, while LEA has always favored the most cost-effective risk reduction measures, the need to carefully examine the least costly

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[18/]Given PECO counsel's insistence that the alternatives must be "physical <u>additions</u> to the plant" (Transcript, p.20), are we also to understand that <u>modifications</u> to <u>existing</u> plant systems are outside of the scope of the contention?

[19/]Indeed, PECO has stated to the NRC Staff in a response to NRC staff request for additional information that "if the most up-to-date information concerning the dominant accident sequences an associated radioactivity releases were not utilized, the mitigation measures being examined might appear to be cost-beneficial, but in fact would not be since the mitigation design alternatives would not be based on potential actual sequences". PECO letter of June 23, 1989 to USNRC regarding consideration of severe accident mitigation design alternatives. Thus, the submission of the more recent PECO PRA requires LEA to revisit its examination of what risk reduction measures will be most meaningful.

strategies may be emphasized in light of the more recent PRA.[20/] LEA's submissions to the ASLB and to the Court of Appeals explicitly recognized that alternative operating procedures may be part of the best risk reduction package:

> [O]perator action can play an important role in accident mitigation providing there is enough time. Such a strategy could potentially be <u>much more cost effective</u> than dedicated automatic systems with fail-safe initiating methods...[I]t is obvious that changes in current operating procedures ...may offer cost-effective reductions in risk.

"State of the Art of Reactor Containment Systems, Dominant Failure Modes, and Mitigation Opportunities", R&D Associates, January 1984, p.8-8, Joint Appendix, p.255.

To permit PECO to utilize recent risk assessments, unavailable at the time LEA's contention was submitted or at the time it was considered by the Court of Appeals, and yet hold that LEA may not now examine in light of this information the most cost-effective risk reduction alternatives -- which include procedures as "part of a containment mitigation system" as expressly recognized in LEA's earlier filings with the ASLB -- is inconsistent, fundamentally unfair, and would violate the mandate

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20/ The value of such an enhanced focus on possible procedural and operational changes has also been recently (long since the LEA contention DES-5 was before the ASLB) emphasized by the NRC Staff in SECY-88-206 "Status of Mark I Containment Performance Evaluation", July 15, 1988: "Emphasis on improving plant operations is a critical element of the staff's overall closure plan for severe accidents. Among the procedural improvements was a requirement for implementing emergency operating procedures based on the symptoms of events that could lead to accidents, as well as the management of events once an accident had been initiated.". Id., pp.2-3.

of the Third Circuit Court of Appeals.

Thus, alternative procedures for severe accident mitigation were always within the scope of DES-5, as "part of a containment mitigation system" and are within the scope of the proceeding on remand.

VII, CONCLUSION

For all of the reasons set forth above, LEA's proposed alternatives set forth in Attachments 1 and 2 are within the scope of the proceeding.

Respectfully submitted,

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June 30, 1989

LIMERICK ECOLOGY ACTION, INC.
LIST OF PRIMARY CANDIDATES
FOR SEVERE ACCIDENT MITIGATION

Venting/Filter Devices

Much attention has been paid in the past to add-on filtered vented containment systems (FVCS). Such add-on systems have been proposed for a number of European plants, and have been constructed at Barseback (a Swedish ASEA-Atom BWR which is grossly similar to the Mark II design). The cost of such devices is significant, with estimates ranging from $30-$100 million (depending upon design and upon the seismic "pedigree" of the structure).

An FVCS can function to both mitigate consequences (by reducing aerosol releases to the environment) and reduce accident frequency (by reducing the frequency of loss of decay heat removal accidents). Such devices, however, cannot function effectively for containment pressurization phenomena which operate over short time domains, such as high pressure melt ejection/direct containment heating. Thus, the effectiveness of an FVCS is dependent at least in part on most of the core melt accidents being low pressure sequences (i.e., the reactor vessel pressure must be low at the time of vessel failure).

Fortunately, there is an option here that requires only a modest investment and little down time (in fact, prob[illegible] no down time unique to this modification; it can probably be done in the shadow of other outage work during a refueling/maintenance outage). This option involves (as part of the "Bernero fixes") installing a hard pipe vent from the ~~dry~~wetwell to the plant stack. This is the option that was utilized at Pilgrim (the so-called "Direct Torus Venting System" or DTVS). Some plant-specific analysis will be necessary to implement this system at Limerick, but it appears promising as an option. The problem with current venting procedures (which have been in place at all operating BWRs since the NRC approved EOP Rev. 2 in the early 1980s) is that the venting ductwork at most plants will fail at a low internal pressure (a few psi). This results in the discharge of steam to the reactor building, which can result in failure of equipment in the reactor building due to the adverse environment (humidity, steam, and, in some cases depending on the venting strategy, radiation) or due to the inability of maintenance personnel to continue to work on equipment repairs. The hard vent avoids this problem by using a pipe which can withstand the pressure without failure and conduct the steam which is vented from the wetwell airspace to the outside environment (preferable up the plant stack to take advantage of an elevated release point.

Containment Spray/Flooding Modifications

It has been suggested that a "sure" way to reduce consequences is to flood the drywell when core damage is imminent. This is by no means "sure" (e.g., what happens is, high pressure melt ejection occurs into a pool of water - a fairly large steam explosion seems plausible), and is probably not necessary.

What is needed here is additional assurance of getting water onto the core debris to promote solidification and to hold down the aerosol source term (in addition, if you can spray with it, you can inject water into the reactor vessel as well as long as the pressure is low). Boston Edison Company, as part of its Safety Enhancement Program (SEP) modified the drywell spray nozzles by capping six of seven spray locations on each spray head. This reduces the spray flow to a point where any reasonable source of water can be used to develop containment spray (RHR, service water, fire protection system water, etc.). Piping interconnections may be needed between RHR and the fire protection water system and/or the service water system. This is a relatively inexpensive task, and is consistent with the Bernero fixes. Moreover, it is useful for containment spray purposes even if vessel injection is impossible due to high pressure

(pressure reduction and source term reduction).

One final factor may be worth consideration. Henry, et al., (Fauske & Associates) have performed small-scale experiments which provide some indication that direct spray of water onto simulated core debris greatly enhances cooling of the debris (this may be due to disruption of the debris surface resulting in enhanced cooling due to the larger surface area). If these experiments are applicable to reactor situations, it may be advisable to consider running a small line from the drywell spray rings to the vicinity of openings in the pedestal and orienting spray nozzles at the likely exit paths of core debris from the pedestal. This design modification could support core debris cooling at the same time that the overall sprays provide containment cooling and fission product source term reduction.

Containment Heat Removal Augmentation Modifications

Some studies have suggested a variety of plant modifications to enhance heat removal, such as heat pipes, fan coolers, spray coolers, extra heat exchangers, etc. Most of these schemes would either be difficult to implement (due to space limitations in the drywell and extensive modifications and additional containment penetrations) or require more R & D before they could be engineered and implemented.

One potential candidate for Limerick, however, is an augmented suppression pool cooling function. As envisioned in an NRC-sponsored report, this system would put a heat exchanger in the suppression pool through which a diesel-driven pump would pump water through the containment to remove heat on a once-through basis (water from the ultimate heat sink).

Spent Fuel Pool Accident Risk Modifications

Recent studies of spent fuel pool risks at a BWR (Vermont Yankee) and a PWR (H.B. Robinson) indicate that there is a potential for a self-sustaining zircalcy fire to result in a large radiological release from the spent fuel pool, particularly where re-racking has taken place. This risk can be minimized at the very least by licensing a dry cask storage form of Independent Spent Fuel Storage Installation (ISFSI) at the site, and removing spent fuel from the spent fuel pool after one year's cooling. This minimizes the amount of fuel in the pool, and, if done early in plant life, eliminates the need to re-rack. Re-racking is costly, and if it can be avoided, this should be attractive to the utility.

Licensing of ISFSIs is covered by 10 CFR Part 72. We estimate that it would take from 4-6 years to prepare an application, file it, get it reviewed, get a construction permit/operating license, and complete construction of the first dry storage units and bring them into operation. This should easily be within the reach of PECo for Limerick for Unit 2 (and perhaps for Unit 1 as well).

Human Factors Modifications (Including Procedures)

Recently, General Electric Company completed an upgrade of the generic Emergency Operating Procedures (EOPs) Revision 4 for the BWR Owners Group (BWROG). EOP Rev. 4 explicitly extends emergency procedures into the severe accident domain for the first time. EOP Rev. 4-based procedures have already been implemented at Pilgrim and Shoreham. Implementation of EOP Rev. 4 has been approved by the NRC staff in a recent SER, and represents a BWROG commitment to NRC. It is also part of the Bernero fixes. We recommend its inclusion in a mitigation/prevention package.

Another human factors area of merit is in responding to seismic events. Considering the contribution of seismic events to core damage frequency (6% of core damage frequency by NRC staff estimate, 24% by PECo estimate), it is eminently reasonable that there should be plant-specific procedural guidance for operators in responding to seismic events. The procedures should explain how such events can impact the plant, point out vulnerabilities, and lay out alternative means for accomplishing safety functions. Such procedures should also include lists of relays and breakers in systems which are relied upon a primary or alternative means to perform safety functions. Relay and breaker chatter as a result of seismic events were not considered in the Limerick SARA seismic PRA, but have been identified elsewhere (including the NUS-performed Kuosheng PRA) as potentially important risk contributors. Further, a recommendation that the plant design be reviewed and that chatter-vulnerable relays and recommendation that the plant design be reviewed and that chatter-vulnerable relays and breakers be replaced with more resistant designs should be considered to reduce the vulnerability to this problem).

A final human factors item that might be considered is to require PECo to expedite the control room design review (if it hasn't yet been done) and to expedite implementation of fixes for human engineering deficiencies (HEDs) if the review has been performed. This should help operator response to severe accidents in general.

Seismic Modifications

The Limerick PRA and the Brookhaven review of the PRA identified as an important part of the seismic risk the failure of the reactor enclosure and control structures wall at 0.90 g (the PRA estimated 1.05g). It is plausible that modifications to this wall could be identified that would sufficiently improve the fragility of this wall to reduce its importance to risk. Engineering analysis would need to be done to evaluate whether this is possible.

Recent studies have identified the potential for chatter of relays and breakers to cause system failures which can contribute to seismic core damage frequency. Such failure modes were assumed in the Limerick seismic PRA (SARA) to be fully recoverable. This is a potentially optimistic assumption. There needs to be a plant-specific assessment to evaluate whether there are any chatter-prone relays and breakers in risk significant systems at Limerick, and, if so, to replace those components with chatter-resistant designs. In addition, it may be desirable to produce operator procedures for use following an earthquake to guide them through verification and resetting of breakers and relays.

Reduction of Transient Initiator Frequency

It is well known that accident sequences initiated by transient events dominate overall core damage frequency for BWRs, and for Limerick and Shoreham in particular. This being so, one straight-forward way to reduce the frequency of severe accidents is to reduce the frequency of transient initiating events. The NRC has been encouraging the industry to do just this, and industry has responded with an active program in this regard. NRC's Office for the Analysis and Evaluation of Operational Data (AEOD) puts out periodic reports (AEOD annual reports and Performance Indicator reports) in which scram frequency data is provided. In addition, a recent AEOD study of new plant performance includes such data. This data is most often reported in terms of unplanned scrams per 1,000 critical hours. It can, however, be converted to scrams per year relatively easily.

In Limerick's first 4862 critical hours (before commercial operation), the plant experienced 4 scrams, for a scram rate of 0.82 scrams per 1,000 critical hours. Assuming this rate obtains over the course of an average year, this works out to 5.5 scrams per year. In 1987, Limerick experienced 2 scrams in 6151 critical hours (a rate of 0.33/1,000 critical hours). In cor rast, the Limerick PRA estimated 9.08 scrams per year, while the Brookhaven review of the Limerick PRA estimated 13.02 scrams per year. If Limerick can maintain this performance, actual risk reduction shall have occurred compared with the level of risk predicted in the PRA.

It would seem sensible, therefore, that if such a program is not already in effect that PECo be required to implement a formal scram reduction program. This should be relatively inexpensive addition to the scram analysis required by post-Salem ATWs procedures, and should enable lessons learned to be applied toward avoiding future scrams in a structured manner.

In addition, given the importance of some systems to risk, it would seem to make sense for PECo to evaluate the potential benefits from implementation of a reliability-centered maintenance program. In such a program, reliability data are used to predict when component failures are likely to occur and to take action (i.e., preventive maintenance) to avert the failure.

Additional reduction of scram frequency might also be obtained by reviewing the technical specifications to see if some can be relaxed to avoid unnecessary shutdowns (manually-initiated shutdowns also carry with them some risk). A number of nuclear power plants have used their PRA studies in such applications (among them LaSalle, Seabrook, and Byron).

Reactor Vessel Depressurization System Modifications

The NUREG/CR-4920, Vol. 2 report identifies the modification of the ADS at Limerick as a way to reduce core damage frequency by a factor of two. If such a modification has not been accomplished, it would make sense to include it as a risk reduction option. Moreover, additional improvements in ADS reliability might be identified through a safety system functional inspection type of analysis. (For example, BECo implemented modifications at Pilgrim to provide additional bottled nitrogen gas to assure long-term availability of ADS during station blackout sequences. It is also possible to modify ADS designs to permit actuation of SRVs while the containment pressure is high; some SRV designs cannot accomplish this, and the valves go closed when containment pressure rises above their design capabilities. Enhanced ADS reliability is particularly important to avoid high pressure melt ejection/direct containment heating phenomena (which could lead to early containment failure) and to take advantage of alternative sources of vessel injection.

Current "Best Estimate" Risk Reduction Package for Limerick

a. Implementation of a hard-piped wetwell vent.

b. Evaluate and implement alternative vessel injection/ drywell spray water sources (optimize what is available, and evaluate whether other sources could be added, similar to BECo's addition of a diesel-driven fire protection system water pump).

c. As necessary, modify the drywell sprays to permit the use of alternative water sources, to spray into the pedestal, and to spray the area outside the pedestal where there are openings from the pedestal to the drywell.

d. Implement Rev. 4 of the Emergency Operating Procedures (EOPs) on a plant-specific basis, and review other pertinent procedures to upgrade their capabilities to aid in operator response to severe accidents. The goal here is to move toward accident management.

e. Implement reliability improvements to the ADS.

f. Implement a scram frequency reduction program.

g. Evaluate the need to replace any chatter-prone relays and breakers in risk significant systems with chatter-resistant designs.

h. Evaluate the potential need for other fixes (e.g., extra diesel generator, removal of AC/DC dependencies on venting and alternative vessel injection, diesel-driven decay heat removal pump and heat exchanger for containment heat removal, etc.).

i. Evaluate potential seismic risk reduction possibilities (e.g., strengthening the reactor enclosure and control structures wall).

j. spent fuel proof accident risk modification.

SUPPLEMENTAL
LIST OF LITIGABLE SEVERE ACCIDENT MITIGATION ALTERNATIVES FOR LITIGATION OF LIMERICK ECOLOGY ACTION, INC. CONTENTION ON SEVERE ACCIDENT MITIGATION ALTERNATIVES FOR THE LIMERICK NUCLEAR GENERATING STATION

MITIGATION ALTERNATIVE	REFERENCE
Alternatives Identified to ASLB/ALAB	
Mode of operation	SARA/EROL Section 7 Contentions filing of August 31, 1983 (Joint Report of LEA, Staff and Applicant) (J.A. pp.84,104)
Procedures	SARA/EROL Section 7 Contentions filing of August 31, 1983 (Joint Report of LEA, Staff, and Applicant) (J.A. pp.84,104)
Alternatives described in Beyea,Jan and Von Hippel, "Nuclear Reactor Accidents: The Value of Improved Containment", Center for Energy and Environmental Studies, Princeton University (PU/CEES Report #94), Jan. 1980	Id., at J.A. p.106
Alternatives described in NUREG/CR-0850 Nov. 1981, "Preliminary Assessment of Core Melt Accidents at the Zion and Indian Point Nuclear Power Plants and Strategies for Mitigating their Effects"	Id., at J.A. p.106
Filter venting of containment	LEA's Reply to Applicant and Staff Response to Severe Accident Risk Assessment Contentions (J.A. p. 113)
More reliable containment heat removal subsystems	Id., at J.A. p. 113
Alternatives under examination in Commission severe accident research program	Id., at J.A. p. 118

ATTACHMENT 2

Filter vented containments	Id., at J.A. p. 120
Filter venting of the containment-Inside NRC vol.5 no.18 (Sept. 5, 1983)	Id., at J.A. p. 122
Alternatives identified in NUREG/CR-1029, "Program Plan for the Investigation of Vent-Filtered Containment Conceptual Designs for Light Water Reactors" (Sandia, Oct. 1979)	Id., at J.A. p. 122
Various options for core retention identified in NUREG/CR-2155 "A Review of the Applicability of Core Retention Concepts to Light Water Reactor Containments" (Sandia, Sept. 1981)	Id., at J.A. p. 123
variations of filtered-vented containment systems (Proposed Policy Statement on Severe Accidents and Related Views on Nuclear Reactor Regulation, 48 Fed. Reg. at 16019 (April 13, 1983)	Id., at J.A. p. 123
Alternatives identified in NUREG/CR-2666, Chapter 7 "Further Considerations of Mitigative Features for Specific Plants: Limerick" in PWR Severe Accident Delineation and Assessment	Id., at J.A. p. 127
Alternatives identified in R&D Associates reports for Contract NRC-03-83-092	Id., at J.A. pp. 127-8
strategy to address failure mode of overpressure failure with either wetwell or drywell break (NUREG/CR-2666, p.7-6)	Id., at J.A. pp.143
filtered vented containment system (NUREG/CR-2666, p.7-9)	Id., at J.A. p. 146

upgrading performance of containment sprays to cope with severe environmental conditions in accident	Id., at J.A. p. 146
filter venting strategies suggested by work of A.S. Benjamin and F.T. Harper in "Risk Assessment of Filtered Vented Containment Options for a BWR Mark I Containment" Proceedings of the International ANS/ENS Topical Meeting on Probabilistic Risk Assessment, Sept. 1981	Id., at J.A. pp.146; 148 151
protection of diaphragm for sequences that lead to containment failure caused by diaphragm failure by modifying the region under the reactor vessel (NUREG/CR-2666, p.7-12)	Id., at J.A. p. 149
heat removal from containment by low volume flow vent-filtered system, heat pipe or containment spray system (NUREG/CR-2666, p.7-13)	Id., at J.A. p.150
increased reliability of suppression pool cooling with system that could be driven from outside containment, and closed loop heat exchange process	Id., at J.A. p. 150
high-volume vent-filter or high capacity sprays "if operated in a timely manner", thus requiring procedural alternatives to assure timely spray operation	Id., at J.A. p.150

measures to assure core debris bed coolability within pedestal, including e.g., rubble bed, suitable flow passages in pedestal wall, and measures identified by Swanson in "Core Melt Materials Interaction Evaluation" Annual Progress Report April 1980 to March 1981, ASAI Report No. 81-001.	Id., at J.A. p.151-2
Alternatives identified in NUREG/CR-3028 "A Review of the Limerick Generating Station Probabilistic Risk Assessment"	Id., at J.A. p. 153
Alternatives identified in NUREG/CR-3299, "Core Melt Materials Interactions Evaluation"	Id., at J.A. p. 153
Alternatives identified in NUREG/CR-2182 "Station Blackout at Browns Ferry Unit 1 - Iodine and Noble Gas Distribution and Release" (Sept. 1982)	Id., at J.A. p. 153
Alternatives identified in NUREG/CR-2672 "SBLOCA Outside Containment at Browns Ferry Unit 1 - Accident Sequence Analysis" (November 1982)	Id., at J.A. p. 154
Alternatives identified in NUREG/CR-2973 "Loss of DHR Sequences at Browns Ferry-Unit 1 Accident Sequence Analysis" (May 1983)	Id., at J.A. p. 154
Alternatives identified in R&D Monthly Project Status Reports Contract NRC-03-83-092	Id., at J.A. pp.155-173
Water cooled crucible core retention device	Id., at J.A. p. 166

flooded thoria rubble bed core retention device	Id., at J.A. p. 166
water cooled refractory tiles core retention device	Id., at J.A. p. 166
pebble-bed covering cooling coils core retention device	Id., at J.A. p. 166
high-alumina cement covering cooling coils core retention device	Id., at J.A. p. 166
magnesium dioxide covering cooling coils core retention device	Id., at J.A. p. 166
zirconium dixoide covering cooling coils core retention device	Id., at J.A. p. 167
graphite covering cooling coils core retention device	Id., at J.A. p. 167
borax bath (thick layer of borax bricks sealed in stainless steel, covering the bottom of the reactor cavity) core retention device	Id., at J.A. p. 167
heavy metal bath (lead, uranium, or copper)	Id., at J.A. p. 167
iron oxide (layer of iron oxide over cooling coils)	Id., at J.A. p. 167
basalt concrete and basalt rubble bed core retention device	Id., at J.A. p. 167
sand core retention system	Id., at J.A. p. 167
iron core retention system	Id., at J.A. p. 167
flooded cavity (water added to flood entire cavity to vessel for core material to be kept dispersed enough to remain quenched)	Id., at J.A. p. 167

other active cooling systems (special jackets and piping system in and around the reactor vessel with intention of retaining the molten core within the reactor vessel)	Id., at J.A. p. 168
alternatives for overpressure control from hydrogen or hydrogen burning including oxygen exclusion, oxygen removal, oxygen dilution, igniters, fans	Id., at J.A. p. 168
overpressure control from attack on concrete including special concrete composition of reactor cavity and basemat to limit release of noncondensible gases on core-concrete attack, and thin basemat compositon	Id., at J.A. p. 168
overpressure control by venting the containment building with vent to tall stack, vent to receiver (another large, closed building to provide larger total expansion volume and greater cooling) and vent to condenser-filter such as sand beds, gravel beds, scrubbers, gravel/sand, water pools, sand filters, charcoal filters, chemical scrubbers, all in various combinations	Id., at J.A. pp. 168-9
overpressure control by containment heat removal with heat pipes, modified heat pipes, heat exchangers, spray coolers, fan coolers, secondary suppression pool, and more reliable residual heat removal system by increasing redundancy and ruggedness of RHR system	Id., at J.A. pp. 169-170
containment protection against missiles - various structures designed to protect the containment penetrations or walls against flying debris or thrashing	Id., at J.A. p. 170

piping inside containment	
special containment structures such as underground siting of containment vessel, berm shield, double containment, containment strength improvements of pressure ratings, increased volume of containment building, and strengthen safety systems by means of armor, bunkers, and heavier construction	Id., at J.A. p. 170
fission product removal systems such as enhanced containment spray systems, and gas treatment system (special recirculating treatment system to remove fission products from the containment gas volume)	Id., at J.A. p. 170
Alternatives identified in documents identified in Appendix A to NRC Response to FOIA 83-432, documents 1 - 38	Id., at J.A. pp. 176-8
Alternatives identified in LEA Contentions on the Environmental Assessment of Severe Accidents as Discussed In the NRC Staff DES, Supp. 1	J.A. pp. 179-183; 189-191
Alternatives identified in R&D Associates Monthly Project Status Reports NRC Contract NRC 03-83-092 and other documents attached to LEA Statement of Significance of NRC Severe Accident Mitigation Systems Contract Documents to LEA Contention DES-5	J.A. pp. 193-256
Alternatives identified in "State of the Art of Reactor Containment Systems, Dominant Failure Modes, and Mitigation Opportunities", Jan. 1984	J.A. pp. 233-256

"operator action" as part of a "containment mitigation system", defined as a cooperative combination of devices, subsystems, and components: "operator action can be a part of such a system" and "operator action or modification of existing equipment can possibly perform as well as dedicated hardware in some cases and at lower cost". "State of the Art of Reactor Containment Systems, Dominant Failure Modes, and Mitigation Opportunities", Jan. 1984 Final Report, p.1-5	J.A. p. 237
"operator action can play an important role in accident mitigation providing there is enough time. Such a strategy could potentially be much more cost effective than dedicated automatic systems with fail-safe initiating methods....[I]t is obvious that changes in current operating procedures both inside the plant... and outside...may offer cost-effective reductions in risk.	J.A. p. 255

<u>Alternatives Identified in Documents Identified to ASLB/ALAB</u>

containment heat removal (energy removal through containment heat removal-active or passive)	NUREG-0850, "Preliminary Assessment of Core Melt Accidents at the Zion and Indian Point Nuclear Power Plants and Strategies for Mitigating Their Effects", Table 5.1, p.5-5
containment-atmosphere removal (energy removal through containment-atmosphere removal- filtered vented containment systems)	Id.
increased containment volume (energy dilution through increased containment volume)	Id.

suppression of the burning of hydrogen and other combustible gases -energy-release control through suppression of burning (e.g., adding inert gases, Halon, water mists)	Id.
controlled burning of hydrogen and other combustible gases (energy release management through controlled burning of hydrogen and other combustible gases, e.g., ignition systems)	Id.
core retention devices-energy release control and core mass management through core retention devices (core catchers, core ladle, cavity flooding, and active and passive cooling)	Id.
missile shields- kinetic energy dissipation of missiles	Id.
strengthening of containment structures - energy absorption enhancement through strengthening of containment structures	Id.
containment heat removal alternatives such as heat pipes with input surface in the drywell region and discharge surface to the atmosphere outside, cold water spray condensers in the drywell, or surface-type heat exchangers to cool suppression pool water	"State of the Art of Reactor Containment Systems, Dominant Failure Modes, and Mitigation Opportunities", R&D Associates, RDA-TR-127301-001, Final Report January, 1984, p.3-39 to 3-40

containment venting of clean steam and nitrogen directly to surroundings and venting smaller quantities of contaminated steam and gas through condensers and filter beds. Options also include those examined by Murfin, NUREG/CR-1410, "Report of the Zion/Indian Point Study: Vol.I, 1980, Levy, "Review of Proposed Improvements, Including Filter/Vent of BWR Pressure-Suppression..." EPRI NP-1747, Ahmad, et al., NUREG/CR-2666, "PWR Severe Accident Delineation and Assessment", and Reilly, "Conceptual Design of Alternative Core Melt Mitigation Systems for a PWR With an Ice-Condenser Containment" NUREG/CR-3068 (1982) [note that the Reilly study described as including designs suitable for the Mark II]	Id., at p. 3-41
core retention or debris control	Id., at p.3-41
combustible gas control - while H2 control is provided in Mark II by deinerting containment with nitrogen, additional measures for hydrogen control may be needed (Papazoglou, NUREG/CR-3028 cited) to reduce the danger of flammability during service deinerting	Id.
increased containment mass holding capability with increased volume, increased pressure capability, improved pressure suppression capability	Id., at 3-42
protection for containment penetrations	Id.
vent-filtered containment options described throughout the document	NUREG/CR-1029, "Program Plan for the Investigation of Vent Filtered Containment Conceptual Designs for Light Water Reactors", Oct. 1979

Alternatives Identified In or Suggested By Documents
<u>Published After the Denial of the LEA Contention</u>

modifications to reduce seismic risk	NUREG-1068, "Review Insights on the Probabilistic Risk Assessment for the Limerick Generating Station", August 1984
safety assurance program	Id., pp.8-4 to 8-5
alternatives identified in NUREG/CR-3908, "Survey of the State of the Art in Mitigation Systems", July 1984	NUREG/CR-3908, "Survey of the State of the Art in of Mitigation Systems", July 1984
alternatives identified in NUREG/CR-4920, "Assessment of Severe Accident Prevention and Mitigation Features : BWR Mark II Containment Design NOTE: these include plant features and operator action/ procedures	NUREG/CR-4920, "Assessment of Severe Accident Prevention and Mitigation Features", July 1988
alternatives identified in NUREG/CR-4244, "Strategies for Implementing a Mitigation for Light Water Reactors", January 1988	NUREG/CR-4244, "Strategies for Implementing a Mitigation Policy for Light Water Policy Reactors", January 1988
alternatives identified in Boston Edison Co., "Report Pilgrim Station Safety as Enhancements" as revised NOTE: these alternatives include both physical and operational plant changes	Boston Edison Co., "Report on Pilgrim Station Safety on Enhancements", July 1987 and revised
supplemental containment system and other modifica- cations as proposed and installed for the Shoreham Nuclear Power Station	various documents of Long Island Lighting Co. for Shoreham Nuclear Power Station, including the "Shoreham Nuclear Power Station Probabilistic Risk Assessment With the Supplemental Containment System", February 1988; SNRC-1424 March 1988 (Response to NRC Staff Additional Questions)

alternatives suggested by the GESSAR II/BWR 6 "advanced reactor design"	NUREG-0979, SER related to the final design approval of the GESSAR II BWR/6 Nuclear Island Design", as supplemented (1986)
alternatives identified in NUREG/CR-4243, "Value/Impact Analysis for Evaluating Alternative Mitigation Systems", January 1988	NUREG/CR-4243, "Value/Impact Analysis for Evaluating Alternative Mitigation Systems" January 1988
alternatives identified in NUREG-1150, "Reactor Risk Reference Document", 1987	NUREG-1150, "Reactor Risk Reference Document" 1987
operational alternatives identified or suggested by NUREG/CR-4177, "Management of Severe Accidents", May 1985	NUREG/CR-4177, "Mangement of Severe Accidents: Extending Plant Operating Procedures into the Severe Accident Regime", May 1985
alternatives identfied in NUREG/CR-4025,"Design and Feasibility of Accident Mitigation Systems for Light Water Reactors", August 1985 see esp., pp.3-24 to 3-77	NUREG/CR-4025, "Design and Feasibility of Accident Mitigation Systems for Light Water Reactors", August 1985

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of	)	
	)	Docket Nos. 50-352
Philadelphia Electric Company	)	
	)	
(Limerick Generating Station,	)	Severe Accident Mitigation
Units 1 and 2)	)	

CERTIFICATE OF SERVICE

The undersigned counsel hereby certifies that a true and correct copy of "Memorandum of Limerick Ecology Action, Inc. Pursuant to Prehearing Conference Order of Atomic Safety and Licensing Board of June 9, 1989" was served upon the following persons by first class mail this 30th day of June, 1989.

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