June 4, 1984

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
PHILADELPHIA ELECTRIC COMPANY	)	Docket Nos. 50-352
	)	50-353
(Limerick Generating Station, Units 1 and 2)	)	

TESTIMONY OF SARBESWAR ACHARYA REGARDING
RESPONSES TO CITY CONTENTION CITY-15 RELATED
TO THE LIMERICK FINAL ENVIRONMENTAL STATEMENT

Q1. Dr. Acharya, please state your name, address and position with the U. S. Nuclear Regulatory Commission.

A1. My name is Sarbeswar Acharya. My business address is U. S. Nuclear Regulatory Commission, Washington, D. C. 20555. I am the Senior Radiological Engineer in Section A of the Accident Evaluation Branch, Division of Systems Integration within the Office of Nuclear Reactor Regulation of the Nuclear Regulatory Commission.

Q2. Have you prepared a statement of your professional qualifications?

A2. Yes. My statement is appended to this testimony.

Q3. Please state the purpose of your testimony and identify your responsibilities therein.

A3. The purpose of my testimony is to respond to the City of Philadelphia's admitted Issue CITY-15 with respect to contamination of open water bodies (and the City's water supplies sourced therefrom) that could occur as a result of fallout subsequent to an

atmospheric release of radioactivity in severe reactor accidents that were analyzed in the Limerick FES. Basically, my efforts were concentrated at the "front" and "back" ends of Dr. Fliegel's and Mr. Wescott's evaluation. Their evaluation is provided in their separate testimony.

Q4. What is Issue CITY-15?

A4. CITY-15 provides:

> The DES does not adequately analyze the contamination that could occur to nearby liquid pathways, and the City's water supplies sourced therefrom, as a result of precipitation after a release. A reasoned decision as to environmental impacts cannot be made without a site specific analysis of such a scenario.
>
> The DES addresses at great length releases to groundwater (DES at 5-34 et seq.), but gives only a cursory and conclusory discussion of contamination of open water (DES at 5-33). This issue is of crucial concern here as the two major water bodies at and near the facility are the City's only water supplies. The City also has open reservoirs within its boundaries which could be contaminated through precipitation. For an issue of such great importance, insufficient consideration has been given here. The mandate of NEPA to take a hard look at environmental consequences has been ignored.

Q5. Please summarize your work related to what you call the "front" end.

A5. I provided the following items to Dr. Fliegel and Mr. Wescott for their use in the fallout and water contamination analysis:

a) selection of a severe accident release category from those listed in FES Table 5.11c;

b) a rationale and procedure for using the CRAC code for estimates of the quantities of radionuclides that would be initially deposited on the open water bodies in the site-region and their adjoining catchment (watershed) areas by atmospheric fallout from the selected release category; and

c) a methodology for using the age-specific dose conversion factors, drinking water usage parameters and age-distribution in the general public for calculation of dose from water contamination.

Q6. Which release category did you select, and what is the basis for such selection?

A6. I selected the release category II-T/WW whose specifications are shown in FES Table 5.11c. A description of II-T/WW is given in Appendix H of the FES.

For a detailed probabilistic risk analysis of liquid pathway contamination one would use all of the release categories shown in FES Table 5.11c with their probabilities shown in FES Table 5.11d. Instead of following this approach, however, a much simpler and reasonably bounding type of analysis was performed by selecting one of the release categories from those listed in FES Table 5.11c which involve relatively large quantities of radionuclides in an atmospheric release, and artificially assigning it a probability

which is the sum of the probabilities of all release categories (the sum of the probabilities in FES Table 5.11d is approximately 9 x 10^{-5} per reactor year). This same bounding approach was undertaken by the staff for study of atmospheric fallout on the Great Lakes in the Fermi-2 FES (NUREG-0769, Addendum 1, March 1982). The reason for selecting release category II-T/WW is that the quantities of radionuclides in the atmospheric release associated with it are amongst the highest values for all the release categories in Table 5.11c.

Q7. What is the basis for adopting the CRAC code for estimation of initial deposition by atmospheric fallout?

A7. The atmospheric dispersion model of the CRAC code has the capability of calculating concentrations of radionuclides deposited on the ground below the traveling radioactive plume (in terms of curies per square meter of the ground surface, Ci/m^2) due to the effects of dry and wet deposition processes (collectively known as the process of atmospheric fallout) on the particulate radioactive matter in the plume. If any part of the ground plane is covered by an open water body over which the plume would pass, the radionuclide concentrations in curies per square meter (Ci/m^2) on the ground plane by fallout can be recognized as the initial radionuclide input (Ci/m^2) into that open water body surface.

The dispersion model of the CRAC code also has the capability of calculating the area in square meters (m^2) that would be covered by

the plume (cloud area) as a function of distance from the reactor. At any given distance, deposition on the ground plane over the area that is directly below the cloud can be calculated by multiplication of the cloud area (m^2) and the ground concentration (Ci/m^2) appropriate for that distance.

Therefore, the CRAC code can be adopted for calculations of initial deposition on the ground and the open water bodies in the Limerick site region subsequent to an atmospheric release from a reactor accident.

Q8. How was the CRAC code used for calculations of ground contamination due to initial deposition by atmospheric fallout?

A8. For the CRAC code analysis the Limerick site region is spanned by 34 spatial intervals, beginning at the site and extending up to 500 miles from the site. Ground concentrations of radionuclides (only those of importance to the liquid pathway contamination study of Dr. Fliegel and Mr. Wescott) and the cloud areas over these spatial intervals were calculated only for the selected release category II-T/WW on a conditional basis; that is, conditional on the occurrence of the postulated release.

Since a reactor accident could occur at any time of the year, 91 different accident start times uniformly distributed throughout a one-year period were used to derive probability distributions of radionuclide concentrations and cloud areas for each spatial

interval. For each start time, a string of consecutive representative historical hourly meteorological data following the start time were used for the plume dispersion and fallout calculations. The sampling scheme and the meteorological data used are the same data as used in the Limerick FES for probabilistic analysis of severe accidents. Results from use of the 91 samples of post accident meteorological conditions were 91 different estimates of ground concentrations and the corresponding cloud area for each spatial interval. These estimates provided the basis for deriving probability distributions of the products of these items due to variations of meteorological conditions.

Q9. What was your involvement regarding use of age-specific radiological dose conversion factors, age-specific drinking water usage, and age-distributions in the general population?

A9. I advised Dr. Fliegel and Mr. Wescott in the use of these data following NRC's Regulatory Guide 1.109 "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision I, October 1977.

Q10. Please describe your work related to what you call the "back end".

A10. I have drawn several conclusions from the analysis of Messrs. Fliegel and Wescott. My general conclusions are:

a) A wind direction which would cause a high deposition of radionuclides on one (Schuylkill or Delaware) watershed would generally preclude a high deposition on the other watershed;

b) Strontium-90 (Sr-90) would largely dominate the radiological significance of Philadelphia water supply contamination from an atmospheric release of the type II-T/WW.

Q11. Please provide a perspective regarding contamination of the Schuylkill River conditional upon occurrence of the release category II-T/WW.

A11. For the first year average Sr-90 concentration probability distribution in the Schuylkill River:

a) The probability of not exceeding the 10 CFR Part 20 limit on concentration for unrestricted area use (1 MPC (maximum permissible concentration) which is 300 pico-Curie/liter or 300 pCi/l for Sr-90) is 14%; and

b) The probability of not exceeding 1/3 MPC is less than 5%.

On the other hand, for the average Sr-90 concentration in the Schuylkill five years afer the initial contamination:

c) The probability of not exceeding 1 MPC is 65%; and

d) The probability of not exceeding 1/3 MPC is less than 20%.

An assessment of Dr. Fliegel's and Mr. Wescott's analysis shows that for Sr-90 concentrations in the Schuylkill:

e) The probability of not exceeding 1 MPC during the first two months is 50%, but there is a 99% probability that the concentration would fall below 1 MPC 20 years after the accident; and

f) The probability of not exceeding 1/3 MPC after 30 years is less than 50%, but there is a 99% probability that this concentration would fall below 1/3 MPC 53 years after the accident.

All probability estimates include the probabilities of wind blowing into the 16 direction sectors of the compass centered at the Limerick site.

Q12. What is your conclusion about usability of the Schuylkill river for drinking water after contamination from the II-T/MM release?

A12. According to 10 CFR Part 20.106(e), the allowable level of contamination in unrestricted areas for a population group beyond which radioactive releases would certainly be controlled is 1/3 MPC. However, from the preceding discussion, there is less than a 50% chance that the Schuylkill River contamination would fall below 1/3 MPC after 30 years. Therefore, the Schuylkill River as a source of drinking water given the occurrence of a severe accident and a II-T/WW type release would have a high probability for interdiction for a long period of time.

However, some point of time during the period of interdiction when Sr-90 concentrations in the Schuylkill River would fall to about 1/3 MPC, it is possible that use of Schuylkill water for drinking would be considered.

Q13. What are the estimates of radiological exposure to the population of Philadelphia from drinking contaminated Schuylkill water?

A13. During the period of interdiction in which use of Schuylkill water for drinking would be denied, there would be no radiological exposure to people from the Schuylkill drinking water pathway.

Dr. Fliegel and Mr. Wescott's estimates of population exposures that would result from drinking Schuylkill water without any decontamination after the Sr-90 concentration falls to 1/3 MPC are 1.8×10^6 person-rem whole body dose and 7.2×10^6 person-rem bone

dose for all time (assuming only half of the Philadelphia population is served by Schuylkill drinking water).

However, the above estimates may be only hypothetical because water containing Sr-90 concentrations at 1/3 MPC may not be allowed for drinking. On the other hand, if use of Schuylkill water for drinking would be permitted only after Sr-90 concentration in the river would fall to the current EPA standard of 8 pCi/l in drinking water, then the residual population exposure resulting from such use for all time would be 8% of the above estimates; namely, about 1.4×10^5 person-rem whole body dose and 5.8×10^5 person-rem bone dose.

Q14. Please provide a perspective regarding Delaware River contamination analogous to that for the Schuylkill River, but conditional upon the release category II-T/WW.

A14. Dr. Fliegel and Mr. Wescott's analysis provides the following perspective.

For the first year average Sr-90 concentrations in the Delaware:

a) the probability of not exceeding 1 MPC is 98%;

b) the probability of not exceeding 1/3 MPC is 85%;

c) the probability of not exceeding 15 pCi/l is 50%; and

d) the probability of no contamination is 38%.

Dr. Fliegel and Mr. Wescott's analysis also shows that for Sr-90 concentrations in the Delaware:

e) The probability of not exceeding 1/3 MPC during less than the first two months is 95%, but there is a 99% probability that Sr-90 concentration would fall to 1/3 MPC within 7.5 years after the accident.

Q15. What is your conclusion regarding the usability of the Delaware River for drinking water after contamination from the II-T/WW release?

A15. There is a very high probability that the Delaware water, if contaminated at all, would be interdicted for a period of less than two months (based upon consideration of interdiction until Sr-90 concentrations fall to 1/3 MPC).

Q16. What is your assessment of radiological exposure from use of contaminated Delaware water conditional upon II-T/WW?

A16. During this short period of interdiction in which use of Delaware water for drinking would be denied, there would be no radiological exposure to people from the Delaware drinking water pathway.

Dr. Fliegel and Mr. Wescott's estimates of population exposures that would result from drinking Delaware water without any decontamination after the Sr-90 concentration falls to 1/3 MPC are 1.8×10^6 person-rem whole body dose and 7.2×10^6 person-rem bone dose for all time (assuming that only half of Philadelphia population is served by Delaware drinking water). These estimates

are the same as those presented for the Schuylkill River under similar conditions.

As stated earlier, the above estimates may be only hypothetical because water with Sr-90 concentrations at 1/3 MPC may not be allowed for drinking. On the other hand, if use of Delaware water for drinking would be permitted only after Sr-90 concentration in the river would fall to 8 pCi/l, then the residual population exposures resulting from such use for all times would be about 1.4×10^5 person-rem whole body dose and 5.8×10^5 person-rem bone dose.

Q17. What situations could result in higher estimates of population exposures than you presented before?

A17. The earlier estimates of population exposures are either for Schuylkill contamination or for Delaware contamination. It is highly unlikely that both rivers will be severely contaminated at the same time. However, in the highly unlikely situation of severe contamination of both rivers at the same time, the Delaware river may be the source of drinking water for the whole city (Philadelphia) after an initial period of about two months. This may be possible via restriction of use of Delaware water only for purposes other than drinking as effected by an appropriate drinking water distribution management plan. Under these circumstances the earlier estimates of population exposures would be doubled, but have only a very small likelihood.

Q18. What are the estimated risks associated with Philadelphia drinking water contamination?

A18. The risks of population exposure from Philadelphia drinking water contamination due to II-T/WW are derived from multiplication of the probability of II-T/WW (2×10^{-6} per reactor year) and the estimates of residual population exposures for all time after Sr-90 concentrations fall to 8 pCi/l. The results are 0.3 person-rem whole body dose per reactor year and 1.2 person-rem bone dose per reactor year from II-T/WW. Conservatively, using the sum of probability of all release categories in FES Table 5.11c (which is 9×10^{-5} per reactor-year), the results would be 13 person-rem whole body dose per reactor year and 52 person-rem bone dose per reactor-year associated with all Limerick severe accidents. These results are conservative because not all release categories in Table 5.11c would result in levels of water contamination as high as those from II-T/WW.

Q19. What principal forms of health effects and their risks may result from drinking water contamination discussed earlier?

A19. Radiation doses associated with drinking water for a year contaminated with 8 pCi/l of Sr-90 would be much less than 1 rem to the critical organ; namely, the skeletal bone. Doses delivered to an individual at this rate would not result in early health effects. Estimates of latent cancer fatality due to 1.4×10^5 person-rem whole body dose over all time is 8 cases excluding bone cancer, and bone cancer fatalities due to 5.8×10^5 person-rem bone dose are

4 cases. The risks of these cancer fatalities are about 7×10^{-4} (excluding bone cancer fatality) per reactor year and about 5×10^{-4} bone cancer fatalities per reactor-year from all severe Limerick reactor accidents. These are small by comparison with the estimates shown in FES, Table 5.11h.

Q20. Does this conclude your testimony?

A20. Yes.

PROFESSIONAL QUALIFICATIONS
Dr. SARBESWAR ACHARYA
U.S. NUCLEAR REGULATORY COMMISSION

I am Sarbeswar Acharya, the Senior Radiological Engineer with the Accident Evaluation Branch, Division of Systems Integration, Office of Nuclear Reactor Regulation. I have served on the Commission staff since January of 1977 in several capacities. My assignments have included assessments of radiological consequences to man and the environment of normal and accidental releases of radionuclides from nuclear power reactors, mathematical and computer modeling thereof, assessment of the generation and transport of radioactivity in reactors themselves resulting from accidents, and technical monitoring of Commission-funded confirmatory research and technical assistance contracts for modeling of external and internal radiation dosimetry to calculate age-dependent radiological dose conversion factors. I am presently responsible for developing and applying improved methods of assessing accident risks of reactor operation for use in Environmental Impact Statements. I have participated in accident risk assessments in virtually all nuclear power reactor Environmental Impact Statements since 1980, and aided in formulation of the procedure for the staff implementation of the Interim Policy Statement on "Nuclear Power Plant Accident Considerations Under the National Environmental Policy Act of 1969." I performed the technical analysis for the staff assessment of accident consequences and risks of the Indian Point reactors, and presented expert staff testimony on the subject at the Indian Point ASLB hearing in February 1983.

Prior to joining NRC in 1977, I was employed by the Bechtel Power Corporation for about 3 years. During this period I developed computer models to evaluate the effectiveness of containment sprays containing chemical additives for radioiodine control under accident conditions in pressurized water reactors, developed computer models for assessing decay heat loads in spent fuel pools for design of cooling systems, developed assessment methodologies for evaluating doses to control room operators and the offsite population from accidental releases of radioactivity, and performed nuclear fuel-cycle economic analysis. During the 1970-71, 1971-72, 1973-74 academic years I taught physics and mathematics at Hawthorne School in Washington, D.C. During 1972-73 I was a post-doctoral research fellow at North Carolina A&T State University doing research in molecular physics, and teaching physics and mathematics to science and engineering students.

My academic training consists of undergraduate courses at Utkal University in India during 1948-52 in physics, mathematics, chemistry and biology leading to a B.S. degree in 1952 with emphasis in physics. During 1952-57 I studied at the University of Delhi in India receiving an M.S. degree in physics in 1954 and engaged in graduate-level research in physics. From 1958 to 1966 I taught physics at undergraduate and graduate levels at colleges affiliated to the Utkal University. From 1967 to 1970 I studied and taught physics and related mathematics, and performed research at the University of Maryland. In 1971 I received a PhD from the University of Maryland, with emphasis in theoretical praticle physics and quantum field theory. I have taken

several specialized training courses since receiving my PhD in such areas as nuclear power plant design and operation, professional engineering registration, system reliability, health physics and radiation protection, mathematics and statistics, probabilistic risk analysis, and nuclear reactor safety.

I am a member of the American Nuclear Society and the Health Physics Society.