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 REX G. WESCOTT AND DR. MYRON FLIEGEL
REGARDING RESPONSES TO CONTENTION CITY-15
RELATED TO THE LIMERICK FINAL ENVIRONMENTAL STATEMENT

Q1. Please state your names, your positions and the nature of your work at the Nuclear Regulatory Commission (NRC)?

A1. My name is Myron Fliegel. I am the Leader of the Hydrologic Engineering Section in the Environmental and Hydrologic Engineering Branch, Division of Engineering, Office of Nuclear Reactor Regulation. My duties include supervision of the professional work of the hydraulic engineers in my section and subsequent review of their technical evaluations. A statement of my professional qualifications is attached.

My name is Rex G. Wescott. I am a hydraulic engineer in the Hydrologic Engineering Section. My duties involve preparation of the hydrologic engineering sections of the staff's safety evaluation report and environmental statements. Technical evaluations performed include: radionuclide transport in ground and surface waters, site flooding potential, cooling water availability and other

hydrologic issues associated with nuclear power plants. I have testified previously in this proceeding concerning hydrologic issues in regard to the supplemental water supply system and to a cooling tower collapse due to blast overpressures. A statement of my professional qualifications is bound into the transcript following Tr. 3490 and Tr. 9045. Another copy is attached to this testimony.

Q2. Please state the purpose of your testimony.

A2. The purpose of our testimony is to respond to the City of Philadelphia admitted Issue CITY-15 with respect to contamination of nearby liquid pathways 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.

Our testimony deals with the liquid transport aspects of this contention. It draws upon the separate testimony of Dr. Acharya and of Mr. Lehr.

Q3. What is the specific nature of your testimony?

A3. Our testimony concerns the deposition and runoff in surface water bodies of radioactivity released to the atmosphere as a result of a severe reactor accident at the Limerick Generating Station.

Discussion of the methodology used to model deposition on land and surface water bodies is contained in Dr. Acharya's testimony.

Our testimony presents the resulting probability distributions of long term concentrations of Strontium-90 (Sr-90) in drinking water that would result from this radioactive fallout.

Our testimony also addresses the maximum short term consequences in regard to drinking water contamination that may result from radioactive fallout subsequent to an atmospheric release of radioactivity in a very severe reactor accident at the Limerick Generating Station.

We are jointly responsible for all of the following testimony.

Q4. Briefly describe the Schuylkill and Delaware Watersheds.

A4. The Schuylkill watershed has an area of almost 1,900 sq miles at Philadelphia and an average flow of about 3,000 cfs (2.7×10^{12} liters/year). Existing storage reservoirs control the flow from over 20% of the watershed. In addition, there are desilting basins on the main stem of the Schuylkill River for control of sediment load.

The Delaware watershed has an area of almost 7,781 square miles at Philadelphia, and an average flow estimated to be over 12,000 cfs (1.07×10^{13} liters/year). Storage reservoirs control flow from about 18% of the watershed. Freshwater flow at Philadelphia is regulated by the Delaware River Basin Commission to meet flow objectives at Trenton during drought periods.

Q5. How are these watersheds oriented with respect to one another?

A5. The long axis of the Schuylkill Basin runs in a northwest to southeast direction with the farthest point in the watershed about 50 miles to the northwest of the Limerick site. The long axis of the Delaware Basin runs north-northeast to south-southwest with the farthest point in the watershed about 160 miles north-northeast of the Limerick site. Because the watersheds are oriented in different directions relative to the site, a wind direction which could cause a high deposition on one watershed generally would preclude a high deposition on the other watershed.

Q6. Please describe the models and methodology used to estimate the amount of radionuclides that could be deposited on the Schuylkill and Delaware River Basins as the result of an accident.

A6. As described in Dr. Acharya's testimony, the ground deposition of various radionuclides, as a function of distance from the plant site, was calculated by the CRAC code. The CRAC run made for this calculation used actual meteorological data for the site (the same data used in the Limerick DES/FES) to determine dispersion and deposition of the radioactive "cloud" resulting from a release category II-T/WW. The pattern of dispersion and deposition for a given radionuclide is dependent on the meteorologic parameters at the starting time of the accident and the period thereafter during which the plume passes over the site region. By starting the analysis of the accident at many different times over the year, many

estimates (Q1) of radioactive deposition within any given distance were determined.

Q7. How were the results from the CRAC deposition model applied to the watersheds?

A7. The area around the plant was divided into 16 equal sectors each containing a 22.5 degree arc. For each of these sectors the probability of the wind blowing to it was determined from meteorological data. For each sector, the distance from the plant to the boundaries of the watersheds was determined. Using the CRAC output, and the location of the watersheds relative to the site, the amount of deposition in the watersheds for various wind directions and meteorologic dispersion conditions was determined.

Q8. How were probability distributions for these various depositions determined?

A8. Each deposition has a probability of occurrence associated with it. Given the accident, the probability of occurrence is equal to the probability of the associated starting meteorological condition multiplied by the probability of wind blowing in the proper direction. The depositions were rank ordered from highest to lowest, and the probability of nonexceedance for a given deposition was determined as the sum of the probabilities of occurrence of all depositions lower than that given deposition.

Q9. What is the nonexceedance probability?

A9. The nonexceedance probability is the probability that a given deposition will not be exceeded after the accident (on which the probability distribution is based) has occurred. The nonexceedance probability is equal to one minus the exceedance probability.

Q10. What are the cumulative probability distributions for depositions of Sr-90 on the Schuylkill and Delaware Watersheds?

A10. The cumulative probability distribution for depositions of Sr-90 on the Schuylkill and Delaware watersheds is shown in Attachment 1.

Q11. Briefly, describe what the probability distribution in Attachment 1 shows?

A11. The curve marked Schuylkill watershed shows the non-exceedence probability of a given deposition in that basin given the accident. Thus, the curve shows that there is a 99% chance that less than 160,000 curies of Sr-90 would be deposited and a 52% chance that less than 80,000 curies would be deposited following a category II-T/WW release. Similarly, for the Delaware watershed, there is a 99% probability that less than 140,000 curies would be desposited and a 50% chance that less than 5,000 curies would be deposited. There is about a 40% probability that there would be virtually no deposition in the Delaware basin following the accident.

Q12. Describe the model used to calculate the amount of a radionuclide which could be washed off the watersheds?

A12. The radionuclide runoff model consists of three basic terms. One term describes the initial washoff (within a month or two after deposition) as a fraction of the total radionuclide deposited. Another term describes the annual washoff (primarily due to erosion) as a constant fraction of the total radionuclide inventory available for transport during the year. A third term accounts for radionuclide losses such as from radioactive decay. The pertinent terms and equations are shown in Attachment 2.

Q13. What are some of the assumptions and limitations of the model?

A13. The model assumes that the initial washoff is not dependent on when the accident occurs and that the fraction assumed for annual washoff stays constant and does not vary from year to year. The model is limited to determining radionuclide transport over a period of years.

Q14. Do these assumptions significantly limit the usefulness of the model to predict the total amount of Sr-90 washed off from the watershed into the river?

A14. No. Studies on watersheds in the United States of washoff of Sr-90 deposited by atomic weapons tests in the 1950's and 60's (Ref. 1) have shown the initial washoff of Sr-90 to be only a few percent of the total deposition. Hence, the total amount of washoff is relatively unaffected by changes in the initial washoff coefficient. Also, although the annual washoff rate due to soil erosion would be expected to increase in wet years, the runoff would also increase,

reducing the proportion of the downstream flow actually used for drinking water. For abnormally dry years, although the proportion of downstream flow used for drinking water will increase, we would expect the amount of Sr-90 washed off to decrease. In conclusion, we expect the time averaged concentration levels not to be significantly affected by the occurrence of abnormally wet or dry years.

Q15. Has this modeling approach been used before to calculate drinking water doses from airborne releases?

Q15. Yes, a very similar approach was used by Dr. Richard Codell of the Staff to determine drinking water dose from a hypothesized atmospheric release at the Indian Point Plant (Ref. 2). This approach has also been described in detail by Helton, Muller and Bayer (Ref. 3) as part of a study performed by Sandia National Laboratory.

Q16. How were the model coefficients determined for the model which you used?

A16. The model coefficients were chosen after a review of the coefficients determined for similar models in other watersheds. In our opinion, the most reliable coefficients were those determined by Dr. Codell for the New York City water supply. Dr. Codell used monthly average measurements of Sr-90 in the New York City tap water and corresponding monthly measurements of Sr-90 deposition over the watersheds in the 1950's and 60's to determine coefficients for washoff into the New York water supply reservoirs. After adjustment

for drainage area and runoff, Dr. Codell's coefficients indicated that the fraction of Sr-90 initially washed off is 1.9% and the fraction of remaining Sr-90 eroded off each year is .84%. Dr. Codell also determined that losses of Sr-90 in the watershed, from other than radioactive decay, accounts for over 75% of the Sr-90 that is deposited but never washed off. Radioactive decay accounts for the remainder of the "lost" Sr-90. Based on these results, we chose 2% for the fraction of initial washoff and 1% for the fraction of annual washoff. For conservatism, we assumed that all "lost" Sr-90 would be due to radioactive decay only.

Q17. Why do you consider these parameters applicable to the Schuylkill and Delaware Watersheds upstream of Philadelphia?

A17. Quarterly measurements of Sr-90 were taken in the Schuylkill and Delaware Rivers in the 1950's and 60's. A review of these measurements showed approximately the same concentration of Sr-90 in the Schuylkill and Delaware Rivers as was recorded for the New York City tap water. We therefore concluded that the transport of Sr-90 in the Schuylkill and Delaware Watersheds was very similar to the transport of Sr-90 into the New York City reservoirs, and that the use of similar model coefficients was justified. Also, a study by Menzel (Ref 1) for eight regions in the United States including the Northeast showed the fraction of initial washoff varying from .59 to 2.17% and the fraction of annual washoff varying from .17 to .75%. Hence, the coefficients determined from Dr. Codell's study are in close agreement with those determined for other watersheds.

Q18. Were radionuclides other than Sr-90 considered in the washoff model?

A18. No, because of the relatively slow rate of washoff only the long lived radionuclides such as Sr-90 and Cesium-137 (Cs-137) will contribute significantly to total population dose from drinking Because of the higher ion exchange capacity of Cesium as compared to Strontium, a much smaller quantity of Cesium would be washed off every year from the watersheds even though more Cs-137 is likely to be deposited from the hypothesized atmospheric release. Based on the amount of Cs-137 assumed released, the runoff coefficients which would be applicable to Cesium, and the dose conversion factors from Regulatory Guide 1.109, we conclude that CS-137 would contribute less than 10% to the total dose for various probabilities. The other radionuclide considered for population dose estimates was Sr-90.

Q19. What are your estimates of the concentrations of Sr-90 in the Schuylkill River, Delaware River, and untreated and uninterdicted Philadelphia water supply for the first year following the accident as a function of non-exceedance probability?

A19. The concentrations of Sr-90 in the various watersheds are shown in Attachment 3.

Q20. What is the significance of the cumulative probability distribution of concentrations?

A20. Although the Schuylkill River is likely to be highly contaminated, the Delaware River has only a 2% chance of being above the 10 CFR

Part 20, Appendix B, Table II concentration of Sr-90, which is 300 pico curies per liter. The Delaware River has a 38% probability of not having any Sr-90 from the accident and there is a 50% probability that the concentration in the Delaware River following the accident would be less than 15 pico curies per liter (15 pCi/l). Therefore, it is highly probable that the Delaware River would remain a safe drinking water source after the accident.

Q21. How long would it take for the Schuylkill River concentrations to diminish to the 10 C.F.R. Part 20 limit for Sr-90?

A21. There is a 50% probability that the concentration of Sr-90 in the Schuylkill River would be below the 10 C.F.R. Part 20 limit after, at most, the initial washoff period (1 to 2 months). For the most severe cases, it could take as long as 20 years for concentrations to recede to the 10 C.F.R. Part 20 limit. There is a much lower probability (13%) that the concentration of Sr-90 in the Schuylkill River will be below 1/3 MPC (100 pCi/l) after the initial washoff period. It could take as long as 53 years for the concentrations to recede to 1/3 Maximum Permissible Concentration (MPC). The cumulative probability distributions of time for the Schuylkill River to reach MPC and 1/3 MPC are shown in Attachment 4.

Q22. What is the significance of these concentration levels and recession times in regard to population dose from drinking water?

A22. For our evaluation of radiological impacts, we assumed that the maximum concentration at which human consumption of water will be

permitted is MPC, although consumption might only be allowed at concentrations well below this. The population dose will then be dependant on the concentration limit chosen for permitting consumption. Whatever the concentration at which human consumption is allowed, it may be achieved by treatment, by dilution with "cleaner" water, or by waiting for the water sources concentration to come down to the desired level. We also assumed that unrestricted use of water will be allowed for concentrations at or below the EPA limit of 8 pico-curies per liter. Therefore, the dose to the population of the City will consist of an annual dose from drinking water at a steady concentration of Sr-90, which has been achieved by water treatment or dilution (if required), and a residual long term dose from drinking water during the time that water drops below the concentration until it recedes to essentially zero for a given concentration between MPC and the EPA limits.

If, for example, the concentration of Sr-90 is maintained at the EPA limits (8 pCi/L), then the immediate dose to the population will consist of a constant dose over the period at which the river is above this concentration, and the water must be treated to meet the limit. In addition, a residual dose will be contributed by drinking the water after the concentration in the river has fallen below the EPA limit and removal of Sr-90 has been discontinued.

For purposes of comparison, we have calculated the annual and residual doses for concentrations of Sr-90 at MPC, 1/3 MPC, and the EPA limits. In that the concentration of Sr-90 from one source is likely to be different from the concentration from the other source,

the population doses are calculated for the population normally served from a single source (.8 million people).

Q23. What would be the annual dose to people from ingesting water at concentrations of 1 MPC, 1/3 MPC, and the EPA limits?

A23. The annual dose to people from ingesting water at a concentration of 1 MPC is 1.6×10^5 person-rems (whole body) and 7.2×10^5 person-rems (bone) per source. The annual dose from ingesting water at a concentration of 1/3 MPC is 6.4×10^4 person-rems (whole body) and 2.4×10^5 person-rems (bone) per source. The annual dose from ingesting water at the EPA limits is 5×10^3 person-rems (whole body) and 1.9×10^4 (bone) per source.

Q24. What would be the long term residual doses to people from ingesting water once it has receded to concentrations of 1 MPC, 1/3 MPC, or EPA limits before treatment?

A24. The long term residual dose to people from ingesting water which has receded to 1 MPC is 5.4×10^6 person-rems (whole body) and 22×10^6 person-rems (bone) per source. The residual dose from ingesting water which has receded to 1/3 MPC is 1.8×10^6 person-rems (whole body) and 7.2×10^6 person-rems (bone). The residual dose from ingesting water which has receded to the EPA limits is 1.4×10^5 person-rems (whole body) and 6×10^5 person-rems (bone).

Q25. How were these population doses determined from the deposition of Sr-90 on the watersheds and the concentration in the rivers?

A25. The population dose from drinking water is a function of how many curies of Sr-90 are actually ingested by people. The number of

curies ingested is a function of the number of curies transported by the river during the period of ingestion and the fraction of the river water that is actually ingested.

Q26. How was the amount of Sr-90 transported by the rivers determined?

A26. Using the previously described runoff model, the fraction of Sr-90 that runs off after the initial deposition and the remaining fraction that erodes off every year may be calculated. Taking into account radioactive decay and integrating this expression over infinite time, the fraction of the initial deposition of Sr-90 that eventually finds its way into the river is estimated. For Sr-90, this fraction was determined to be approximately 31% for both the Delaware and Schuylkill River Basins.

Q27. How was the fraction of total flow ingested determined?

A27. The average flow in the Schuylkill River at Philadelphia was determined to be approximately 2.7×10^{12} liters/year from long term flow records. The average freshwater flow in the Delaware River Estuary at Philadelphia was estimated to be about 1.1×10^{13} liters/year. Average drinking water use from each of the rivers was determined using Table E-4 of Regulatory Guide 1.109 (Ref. 4). The total drinking water use from each of the rivers was determined to be 2.7×10^{8} liters/year. Therefore, the fraction of flow used for drinking water was .01% for the Schuylkill River and .0025% for the Delaware River Estuary.

Q28. How was the dose conversion factor determined?

A28. The age and usage weighted dose conversion factor used was the whole body dose conversion factor for Sr-90 as determined from Tables E-11 through E-13 of Regulatory Guide 1.109. The composite dose conversion factor for an assumed distribution of adults, children and teenagers was determined to be 2.21×10^{-3} millirem/pico curie of Sr-90 ingested for the whole body dose and 8.89×10^{-3} millirem/pico curie for the bone dose ingested.

Q29. What is the effect of radionuclide deposition on water supply reservoirs and open storage tanks or basins?

A29. Although deposition of radionuclides on open water bodies can result in immediate contamination, the total amount of radioactivity entering the water supply in this manner will be very small in comparison to that entering the water supply as washoff from the upstream watersheds. Also the City of Philadelphia is located such that a deposition on the reservoirs within the City will not coincide with a heavy deposition on the Schuylkill or Delaware watersheds. Therefore, replacement of the contaminated water with relatively clean water prior to residential distribution would be expected.

Q30. Did you make estimates of effects or consequences for time periods less than 1 year?

A30. Yes, we looked at what river concentrations could be for periods less than a year. We used the deposition on the watersheds calculated with the CRAC code as discussed previously.

Q31. How did you calculate river concentrations?

A31. River concentration is the amount of a nuclide, in Curies, running off the land into the river or depositing directly on the river divided by the total river flow during the period of interest. Measurements of Sr-90 runoff have been made for various river basins as discussed previously. Typical values are a few percent; i.e., it was found that of the Sr-90 deposited on a watershed only a few percent is removed by initial runoff.

Q32. What assumptions and parameters were used in your calculations?

A32. We confined the analysis to the Schuylkill River basin. Because of its lower flow, concentrations would be higher for a given deposition probability than in the Delaware River. This is seen in the cumulative probability distribution curves of river concentration for the two rivers (Attachment 3). We also looked only at the case of maximum deposition in the Schuylkill basin. The maximum deposition in the basin determined using the CRAC code was about 162,000 Curies of Sr-90. Our estimate of concentrations is based on this assumed deposition.

We looked at several time periods and made different assumptions on Sr-90 runoff.

Q33. What is the significance of using a deposition of 162,000 Curies of Sr-90 in your assessment of concentrations?

A33. This quantity of Sr-90 is essentially all of the Sr-90 assumed to be released in the accident sequence considered. A probabilistic assessment of the amount of Sr-90 that would be deposited in the Schuylkill River basin shows that there is less than a 1% chance that it would all be deposited in the basin. There is about a 50% probability that less than half of the Sr-90 would be deposited in the Schuylkill basin. Thus, our analysis of the consequences of all of the Sr-90 being deposited in the Schuylkill River basin is a worst case analysis, and all of our results should be viewed in this context.

Q34. Please discuss your results.

A34. We considered a number of cases. First we considered situations with average Schuylkill River flow. We assumed that 2% of the Sr-90 ran off. This runoff percentage is consistent with measured data for runoff of Sr-90 deposited in many watersheds as a result of fallout from atmospheric weapons testing. We considered the runoff to occur in time periods of a month, a week, and a day. The resulting Sr-90 concentrations ranged from less than 15,000 pCi/l for runoff in a month to about 440,000 pCi/l for runoff in a day.

Q35. How do these concentrations compare to drinking water standards for Sr-90?

A35. The maximum allowable concentrations of various nuclides in unrestricted areas are given in 10 CFR Part 20, Appendix B, Table II. These concentrations are typically used for normal operation rather

than accident conditions. Additionally, 10 C.F.R. § 20.106 allows concentrations to be averaged over periods up to one year. Nevertheless, we thought it would be instructive to compare these concentrations with those we calculated above. The Table II concentration for Sr-90 is 300 pCi/l. The Sr-90 concentrations discussed above range from about 49 times this value for the case of runoff in a month to almost 1500 times this value if runoff were to occur in only one day.

Q36. What about time periods shorter than one day?

A36. For short time periods, the flow in a river and the concentration of a pollutant entering the river as runoff is limited by the response time of the river system. For short time increments, the entire drainage system will not have had enough time to transmit flow and pollutants downstream to the point of interest. For the Schuylkill River this would be the case with time periods less than a day. It is probably also true for time periods somewhat longer than one day, i.e., the shortest time period that all of the Sr-90 runoff (assumed to be 2 percent of the deposition) can flow past the Philadelphia intake is more than one day. The one day time period is a conservative bound.

Q37. Do you conclude that the effects on drinking water would be worse if runoff occurs relatively rapidly?

A37. No. Clearly the concentration of Sr-90 would be higher for rapid runoff. However, what would probably happen is that during the

period of initial runoff, drinking water would not be withdrawn from the Schuylkill. Quick runoff would shorten the time period during which the Schuylkill would not be used for drinking water supply. Because of this, rapid runoff would probably be the more desirable condition.

Q38. Is it possible to have significantly more than 2 percent of Sr-90 runoff?

A38. Yes. Experimental data have shown initial runoff of over 10 percent of deposited Sr-90 on bare plots. We considered the situation where the deposition occurs during a storm in which the ground is already well saturated and there is significant runoff. We assumed 50 percent of all the soluble nuclides would run off and that this would occur in a time period of only one day. We believe that these are extremely conservative assumptions; they are used primarily to bound the problem.

Q39. What assumption did you make about Schuylkill River flow for this scenario?

A39. Clearly, the assumptions we made regarding the high nuclide runoff would be appropriate only during conditions of high river flow. We used the average annual flood flow for this assessment.

Q40. What were your results?

A40. For this scenario, i.e., 50 percent of the deposited nuclides running off in one day during an average annual flood, we estimated the concentration of Sr-90 to be about 950,000 pCi/l. This is over

3,000 times the 10 CFR Part 20 limit for this nuclide. Other nuclides would also be well above their 10 C.F.R. Part 20 limits.

Q41. Would this therefore be a worst case situation?

A41. It would be in terms of high concentration in the river. We have intentionally made very conservative assumptions in order to bound the problem. This scenario of rapid runoff of half of the deposited nuclides, while leading to high river concentrations and thus, high doses to individuals who drink the water, may be more desireable, given an accident, than the more likely scenario of only a small amount of initial runoff. The high runoff scenario would flush a relatively large fraction of the nuclides from the river system during a short period of time when, almost certainly, drinking water would not be withdrawn from the river. Since a smaller percentage of nuclides would remain in the river basin, the total long-term population dose would be smaller for this scenario.

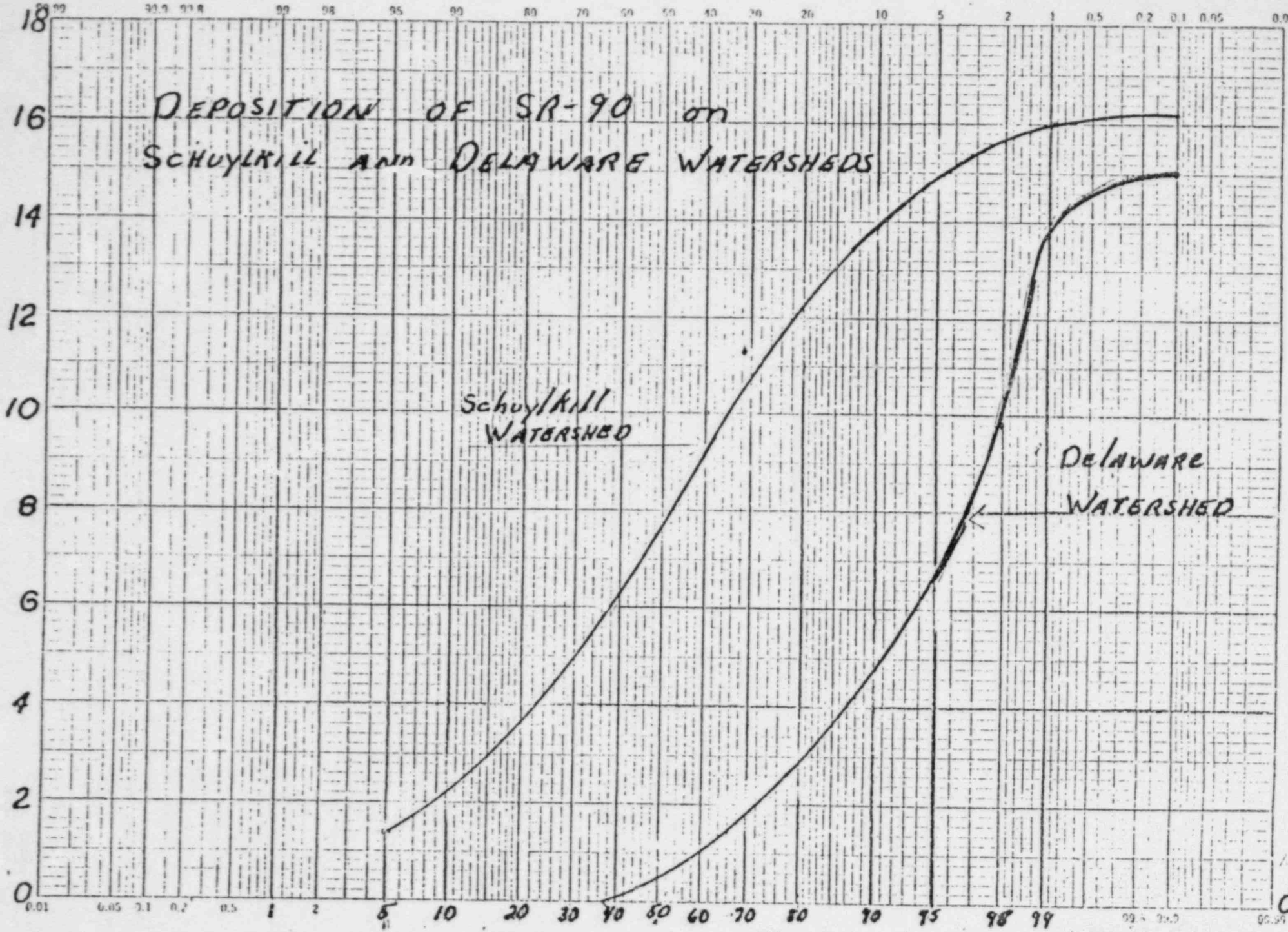
REFERENCES

1. R.G. Menzel, "Land Surface Erosion and Rainfall as Sources of SR-90 in Streams," Environmental Quality, Vol. 3, No. 3, 1974, pp. 219-227.

2. R.B. Codell, "Potential Contamination of Surface Water Supplies by Atmospheric Releases from Nuclear Plants" paper submitted to Journal of Health Physics, 1984.

3. J.C. Helton, A.B. Muller, and A. Bayes, "Contamination of Surface Water Bodies After Reactor Accidents by Erosion of Atmospherically Deposited Radionuclides," paper submitted to Journal of Health Physics, 1984.

4. U.S. Nuclear Regulatory Commission, "Regulatory Guide 1.109 - Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 C.F.R. Part 50, Appendix I," Rev. 1 Oct. 1977.



RADIONUCLIDE RUNOFF MODEL

$$W = \lambda_a \chi_o + \lambda_b \chi(t)$$

where:

W = annual washoff

χ_o = initial deposition of radionuclide

λ_a = fraction of initial deposition washed shortly after deposition

$\chi(t)$ = amount of radionuclide remaining in watershed at time t after initial washoff

λ_b = fraction of remaining deposition washed off per year (assumed to remain constant)

$$dx/dt = -(\lambda + \lambda_b)\chi(t)$$

where:

dx/dt = rate of change of radionuclide after initial washoff

λ = decay constant for radionuclide

$$\chi(t) = (1 - \lambda_a)\chi_o \exp[-(\lambda + \lambda_b)t]$$

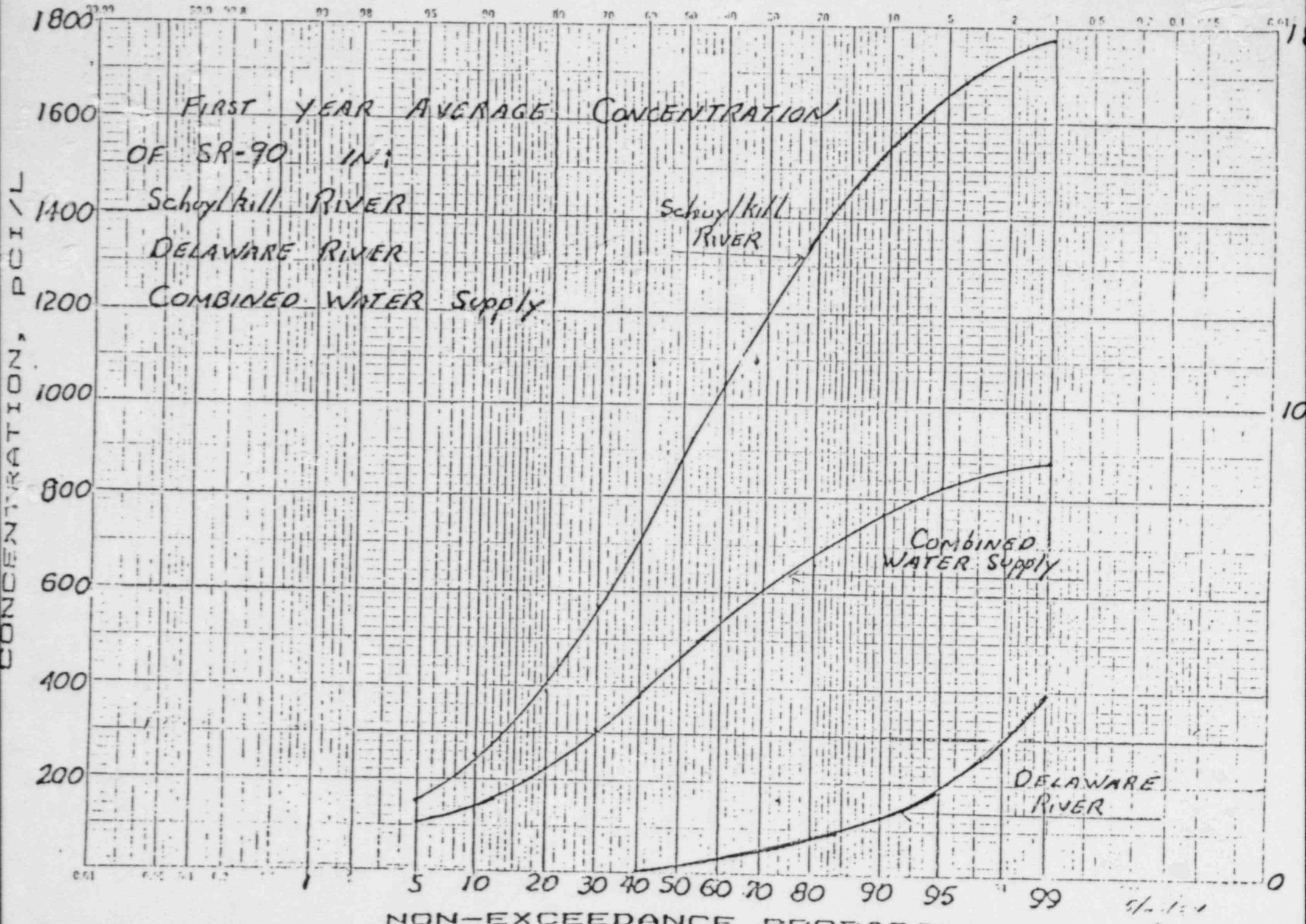
FRACTION OF DEPOSITION WASHED OFF OVER INFINITE TIME

$$W(\infty) = \lambda_a \chi_o + \int_0^\infty \lambda_b \chi(t)$$

$$W(\infty) = \frac{(\lambda_a \lambda + \lambda_b)\chi_o}{(\lambda + \lambda_b)}$$

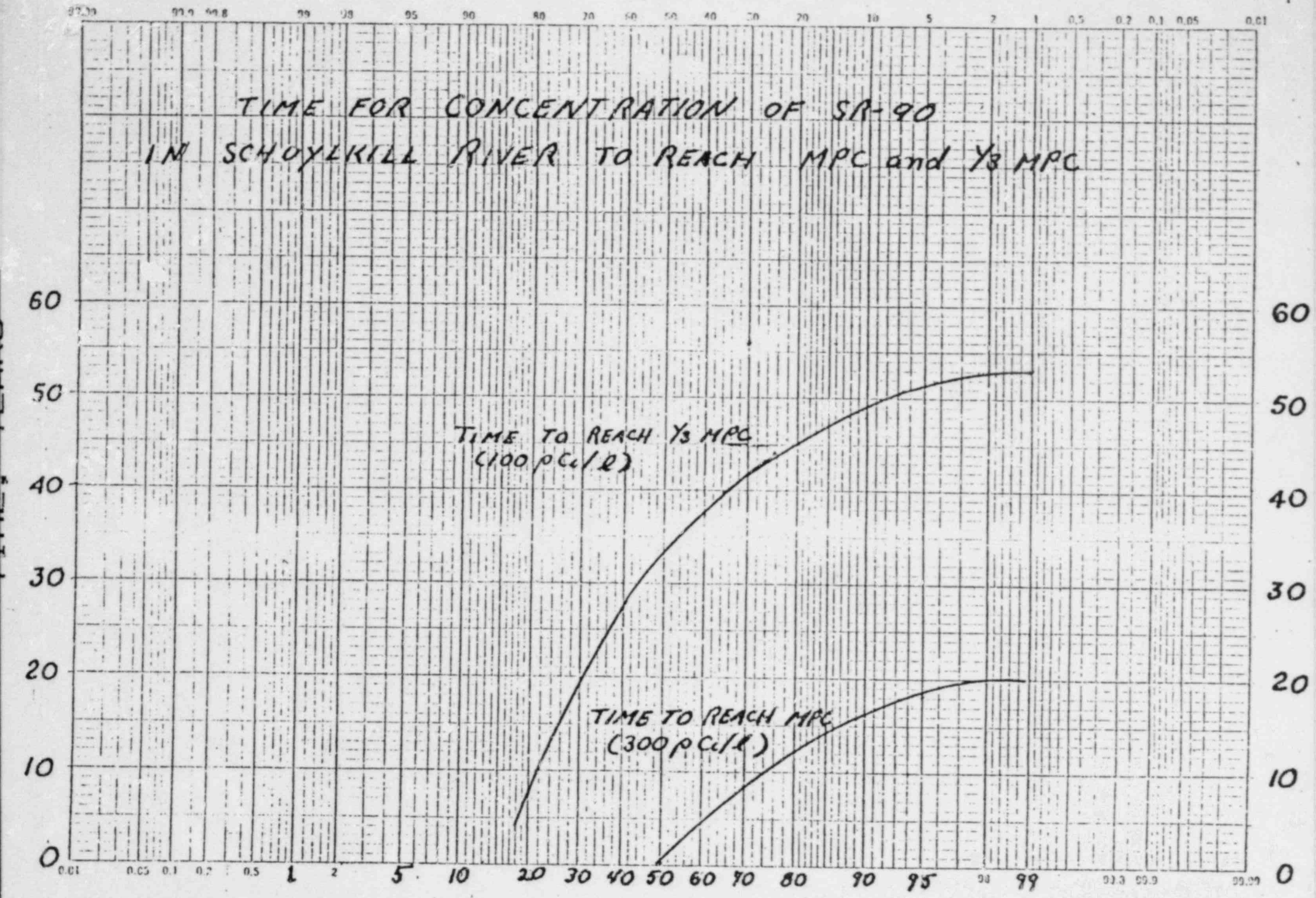
where $W(\infty)$ = the total amount of radionuclide washed off over an infinite time period

ATTACHMENT 3.



KEUFFEL & ESSER CO.

ATTACHMENT 1.



NON-EXCEEDANCE PROBABILITY

5/25/64

Professional Qualifications of
Rex G. Wescott, Hydraulic Engineer
Hydrologic Engineering Section
Environmental and Hydrologic Engineering Branch
Division of Engineering
Office of Nuclear Reactor Regulation

I am a hydraulic engineer in the Hydrologic Engineering Section, Environmental and Hydrologic Engineering Branch, Division of Engineering.

My formal education consists of a B.S. in Physics received from Clarkson College of Technology in Potsdam, New York in 1970, an M.S. in Engineering Science received from Clarkson College in 1974, and approximately 27 graduate credit hours in hydraulics, advanced fluid mechanics, and coastal engineering from Polytechnic Institute of New York and Rutgers University. My graduate study at Clarkson College consisted primarily of courses in surface and subsurface hydrology, water resources engineering, and systems analysis.

My present employment with NRC dated from 1978 when I was employed as hydraulic engineer with the Office of Standards Development. In 1981 I joined the Office of Nuclear Reactor Regulation, Hydrologic and Geotechnical Engineering Branch. My responsibilities in the licensing review of nuclear facilities is in the area of flood vulnerability, adequacy of water supply and surface and groundwater acceptability of effluents.

From 1975 to 1978 I was employed as a Civil Engineer with Ebasco Services, Inc. in New York, New York. I was responsible for conceptual designs of dams, reservoirs, and spillways; preparation of SARs and ERs for nuclear power plant projects; and for studies and reports in other various water-related projects.

From 1973 to 1975 I was employed as a staff engineer with Woodward-Clyde Consultants, Inc. in Clifton, New Jersey. At Woodward-Clyde my responsibilities were very similar to those which I had at Ebasco Services.

I am a registered Professional Engineer in the State of Maryland and an associate member of the American Society of Civil Engineers.

Myron H. Fliegel
Hydrologic Engineering Section
Environmental and Hydrologic
Engineering Branch
Division of Engineering
Office of Nuclear Reactor Regulation

Professional Qualifications

I am the Section Leader of the Hydrologic Engineering Section, Environmental and Hydrologic Engineering Branch, Division of Engineering, Office of Nuclear Reactor Regulation.

My formal education consists of study in physics and mathematics at the City College of New York where I received a B.S. in physics in 1965 and study in geophysics and oceanography at Columbia University where I received a Ph.D. in physical oceanography and limnology in 1972. I have had courses in oceanography, coastal engineering, marine geology, fluid mechanics, ocean acoustics, data analysis, seismology, geophysics, geology, hydrology, advanced physics and mathematics, and engineering management.

I have been the Section Leader of the Hydrologic Engineering Section since February, 1981. I supervise and review the evaluations of hydrologic aspects of nuclear facility sites performed by members of my staff.

My employment with NRC (formerly AEC) dates from August 1974 in the area of hydrologic engineering, physical oceanography, and limnology with the Office of Nuclear Reactor Regulation and for consultation on siting of materials utilization facilities and on environmental matters. My responsibility in the licensing review of nuclear facilities is in the areas of flooding vulnerability, adequate water supply and surface and ground water acceptability of effluents. In addition, I participate in the development of the technical bases for safety guides and standards, and research identification and analysis in these areas of interest.

From 1972 to 1974, I was a Staff Scientist (later Research Associate) at Lamont-Doherty Geological Observatory of Columbia University. I was in charge of the data analysis in connection with a large scale oceanographic effort being conducted in the Arctic. I was responsible for organizing the data, writing and debugging all the computer programs and I participated in the design and procurement of equipment and the evaluation of the data.

From 1965 to 1972, I was a Graduate Research Assistant at Lamont-Doherty Geological Observatory of Columbia University. My dissertation work, which began in 1968, involved a study of the thermal behavior of, and internal waves in, one of the Finger Lakes of western New York. I organized the experiment, procured and set up the equipment, collected and digitized the data, wrote and debugged the computer programs, analyzed the data and evaluated the results. Previously, I was involved in an experiment to measure and analyze deep ocean temperatures and currents near the Pacific Ocean floor off the California coast.

I have published in Limnology and Oceanography, the Journal of Marine Geodesy, the Journal of Geophysical Research and the Journal of Physical Oceanography. I have presented papers at meetings of the American Geophysical Union and the American Society of Limnology and Oceanography.

I am a member of the American Association for the Advancement of Science, the American Geophysical Union and the Society of Sigma Xi.