NUREG-0974

Final Environmental Statement
related to the operation of Limerick Generating Station, Units 1 and 2

Docket Nos. 50-352 and 50-353

Philadelphia Electric Company

U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

April 1984

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ABSTRACT

This Final Environmental Statement contains the second assessment of the environmental impact associated with the operation of the Limerick Generating Station, Units 1 and 2, pursuant to the National Environment Policy Act of 1969 (NEPA) and Title 10 of the Code of Federal Regulations, Part 51, as amended, of the Nuclear Regulatory Commission regulations. This statement examines the environment, environmental consequences and mitigating actions, and environmental and economic benefits and costs. Land use and terrestrial and aquatic ecological impacts will be small. Operational impacts to historic and archeological sites will be negligible. The effects of routine operations, energy transmission, and periodic maintenance of rights of way and transmission facilities should not jeopardize any populations of endangered or threatened species. No significant impacts are anticipated from normal operational releases of radioactivity. The risk of radiation exposure associated with accidental release of radioactivity is very low. The net socioeconomic effects of the project will be beneficial. The action called for is the issuance of operating licenses for Limerick Generating Station, Units 1 and 2.

Further information may be obtained from

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U.S. Nuclear Regulatory Commission
Washington, D.C. 20555
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SUMMARY AND CONCLUSIONS

This Final Environmental Statement (FES) was prepared by the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation (NRC staff).

(1) This action is administrative.

(2) The proposed action is the issuance of operating licenses to Philadelphia Electric Company for operation of the Limerick Generating Station, Units 1 and 2 (Docket Nos. 50-352 and 50-353), located on the Schuylkill River, near Pottstown, in Limerick Township, Montgomery County, Pennsylvania.

Units 1 and 2 each will employ a boiling water reactor to produce up to 3293 megawatts thermal (MWt). A steam turbine generator will use this energy to provide 1055 megawatts (net) of electrical power capacity (MWe) per unit. The exhaust steam in this closed-cycle system will be cooled in two natural draft cooling towers, using water from the Schuylkill River, Perkiomen Creek, and the Delaware River. Cooling tower blowdown water will be mixed with nonconsumed station water and discharged to the Schuylkill River.

(3) The information in this statement represents the second assessment of the environmental impacts pursuant to the Commission's regulations as set forth in Title 10 of the Code of Federal Regulations, Part 51 (10 CFR 51), which implements the requirements of the National Environmental Policy Act of 1969 (NEPA). After receiving, in February 1970, an application to construct Limerick Units 1 and 2, the staff reviewed impacts that would occur during station construction and operation. That evaluation was issued as a Final Environmental Statement - Construction Permit Phase (FES-CP) in November 1973. After this environmental review, a safety review, and an evaluation by the Advisory Committee on Reactor Safeguards, the U.S. Nuclear Regulatory Commission issued Construction Permits Nos. CPPR-106 and 107 on June 19, 1974. The applicant submitted an application for operating licenses (OLs) by letter dated March 17, 1981. The NRC conducted a predocketing acceptance review and determined that sufficient information was available to start detailed environmental and safety reviews. The applicant's Final Safety Analysis Report (FSAR) was docketed on July 27, 1981.

(4) The NRC staff has reviewed the activities associated with the proposed operation of the station and the potential impacts, both beneficial and adverse. The NRC staff's conclusions are summarized as follows:

(a) The Limerick generation station will provide approximately 10 billion kWh of electrical energy annually (assuming that both units will operate at an annual average capacity factor of 55%). The addition of the station will add 2110 MW of operating capacity to the Philadelphia Electric Company system, resulting in increased system and regional reliability (Chapter 6).

(b) Alteration of about 240 ha (595 acres)* of land for the plant has been necessary. This is not significant. (Section 4.3.4)

(c) Operation of the Limerick generating station will not have a significant adverse impact on any terrestrial or aquatic endangered or threatened species (Section 4.3.5).

(d) The water quality of the Limerick source waters for condenser cooling varies from good to degraded. The operation of the Point Pleasant Diversion is expected to result in the delivery of water to Limerick that is higher in quality for several constituents than the Schuylkill River water that will receive the station blowdown (Section 4.3.2).

(e) The creation and operation of the Bradshaw Reservoir, as presently proposed, is judged to have little potential for contamination of either groundwater in the area or nearby existing residential drinking water wells (Section 5.3.2.3).

(f) The operation of the Point Pleasant Diversion will provide water of generally better quality to the middle and lower reaches of the East Branch of Perkiomen Creek. The diversion waters will dilute the wastes discharged to the stream that are responsible for the present degraded water quality in the lower stream reaches (Section 5.3.2.3).

(g) During Limerick operation, the area of the Schuylkill River with a surface temperature in excess of that permitted by applicable water quality standards (i.e., the mixing zone) is expected to be very much smaller than the maximum area permitted by the Delaware River Basin Commission (Section 5.3.2.2).

(h) The water quality of the Limerick discharge, after initial mixing with the Schuylkill River, is predicted to, at times, exceed the applicable quality criteria for some constituents, based on source water maximum constituent concentrations. These exceedances are expected for constituents whose maximum river concentrations also exceed the applicable criteria. Other constituents in the discharge are expected to be present at concentrations below those measured in the river, a result of the higher quality source water used at Limerick (Section 5.3.2.3).

(i) Based on available information, the proposed condenser biofouling control scheme proposed for Limerick would not be expected to have significant adverse effects on human health or plant or animal life in the Schuylkill River considering its designated protected water

*Throughout the text of this document, values generally are presented in both metric and English units. For the most part, measurements and calculations were originally made in English units and subsequently converted to metric. The number of significant figures given in a metric conversion is not meant to imply greater or lesser accuracy than that implied in the original English value.

uses. The proposed infrequent chlorination of the stations cooling towers for biofouling control could result in adverse impacts to recieving water biota. Mitigative measures are identified (Section 5.3.2.3).

(j) The presence of the plant and plant operations will have negligible effect on the 100-year floodplain (Section 5.3.3).

(k) The water level changes in the Delaware River caused by pumping at Point Pleasant for Limerick are insignificant (Section 5.3.3).

(l) Periodic operation of the diesel generators (the predominant contributors to air pollutant discharges) and auxiliary boilers should not have a significant impact on air quality (Section 5.4).

(m) Cooling tower salt drift will not adversely affect native vegetation or agricultural crops in the immediate vicinity of the plant (Section 5.5.1).

(n) The NRC staff has found no evidence to date to support a conclusion that the operation of the Limerick transmission system will have an adverse effect on the health of humans or that its operation will adversely affect plant or animal life (Section 5.5.1.2).

(o) Limerick will utilize four water bodies to provide source and receiving waters for condenser cooling. The Schuylkill River will provide the primary source water and will receive all station effluents. Localized minor effects are possible from impingement and entrainment of fishes and from thermal effluents. The supplemental cooling water withdrawal from Delaware River using state-of-the-art technology will have minor effects only. The transport of diversion water through the East Branch of Perkiomen Creek will alter the headwater section from its present condition, and downstream areas should benefit from improved water quality. The supplemental cooling water withdrawal from Perkiomen Creek using state-of-the-art technology will result in localized effects from entrainment of fish larvae. The overall potential of environmental impact because of the station has been reduced significantly since the FES-CP was issued by the revision of the design for the intakes on the Delaware River and Perkiomen Creek. Concerns raised at the CP stage, therefore, have been resolved (Sections 5.5.2 and 5.6).

(p) The operation and maintenance of the Limerick Generating Station will have no significant impact on the archeological resources or historic sites, with the exception of possible impacts along the transmission corridors. After the NRC staff receives the reports of the archeologic and historic surveys of the transmission routes, the NRC staff will review them in consultation with the State Historic Preservation Officer. If additional action is required, the procedures to mitigate potential impacts will be addressed in the environmental Protection Plan, (Section 5.7).

(q) The overall socioeconomic impact of operating Limerick will be beneficial (Section 5.8).

(r) The risk to public health and safety from exposure to radioactive effluents and the transportation of fuel and wastes from normal operations will be very small (Section 5.9.3).

(s) The environmental impacts that have been considered in the staff's evaluation of the postulated plant accidents include potential radiation exposures to individuals and to the population as a whole, the risk of near- and long-term adverse health effects that such exposures could entail, and the potential economic and societal consequences of accidental contamination of the environment. These impacts could be severe, but the likelihood of their occurrence is judged to be small. This conclusion is based on (a) the fact that considerable experience has been gained with the operation of similar facilities without significant degradation of the environment; (b) the fact that, to obtain a license to operate, the Limerick station must comply with the applicable Commission regulations and requirements; and (c) a probabilistic assessment of the risk based upon the methodology developed in the reactor safety study (RSS), improvements on the RSS methodology including external event analysis, and a sensitivity analysis of offsite emergency response modeling. The overall assessment of environmental risk of accidents, assuming protective actions, shows that the risks of population exposure and latent cancer fatality are within a factor of 30 higher than those from normal operation. Accidents have a potential for early fatalities and economic costs that cannot arise from normal operations; however, the risks of early fatality from potential accidents at the site are small in comparison with risks of early fatality from other human activities in a comparably sized population, and the accident risk will not add significantly to population exposure and cancer risks. Accident risks from Limerick are expected to be a small fraction of the risks the general public incurs from other sources. Further, the best estimate calculations show that the risks of potential reactor accidents at Limerick are within the range of such risks from other nuclear power plants. Based on the foregoing considerations of environmental impacts of accidents, which have not been found to be significant, the staff has concluded that there are no special or unique circumstances about the Limerick site and environs that would warrant special consideration of alternatives for Limerick Units 1 and 2. (Section 5.9.4.6)

(t) The environmental impact of the Limerick station as a result of the uranium fuel cycle is very small when compared to the impact of natural background radiation (Section 5.10).

(u) Tones from the Point Pleasant pumphouse transformers are predicted to be audible and may cause annoyance at a nearby residence. Noise monitoring and, if necessary, mitigative measures to make the tones inaudible will be required of the applicant (Section 5.12.1). At the Bradshaw Reservior pumphouse, noise from transformers and pump motors may be audible at nearby residences. Identified mitigative measures would reduce noise levels to below those likely to cause annoyance and complaints. Ambient noise level monitoring and operational noise level monitoring are recommended (Section 5.12.2).

The applicant has committed to performing these surveys and instituting mitigative measures if necessary, (5.12.2.1, 5.14.4.1, 5.14.4.2). Off-site noise levels in the vicinity of the Limerick site during plant operation are not expected to be high enough above ambient levels to annoy nearby residents (Section 5.12.3). A confirmatory operational noise level monitoring program is recommended for the Limerick site (Section 5.12.3).

(5) This statement assesses various impacts associated with the operation of the facility in terms of annual impacts, and balances these impacts against the anticipated annual energy production benefits. Thus, the overall assessment and conclusion would not be dependent on specific operating life. Where appropriate, however, a specific operating life of 40 years was assumed.

(6) The Draft Environmental Statement and its Supplement were made available, for comment, to the public, to the Environmental Protection Agency, and to other agencies, as specified in Chapter 8. Comments recieved are addressed in Section 9 and the comment letters are reprinted in Appendix A.

(7) The personnel who participated in the preparation of this statement and their areas of responsibility are identified in Section 7.

(8) On the basis of the analyses and evaluations set forth in this statement, and after weighing the environmental, economic, technical, and other benefits against environmental and economic costs at the operating license stage, the NRC staff concludes that the action called for under NEPA and 10 CFR 51 is the issuance of operating licenses for Limerick Units 1 and 2, subject to the following conditions for the protection of the environment. (Section 6.1):

(a) Before engaging in additional construction or operational activities that may result in a significant adverse impact that was not evaluated or that is significantly greater than that evaluated in this statement, the applicant shall provide written notification of such activities to the Director of the Office of Nuclear Reactor Regulation and shall receive written approval from that office before proceeding with such activities.

(b) The applicant shall carry out the environmental monitoring programs outlined in Section 5 of this statement, as modified and approved by the NRC staff, and implemented in the Environmental Protection Plan and Technical Specifications that will be incorporated in the operating licenses for Limerick Units 1 and 2. Monitoring of the aquatic environment shall be as specified in the National Pollution Discharge Elimination System (NPDES) permit.

(c) If adverse environmental effects or evidence of irreversible environmental damage develops during the operating life of the plant, the applicant shall provide the NRC staff with an analysis of the problem and a proposed course of action to alleviate it.

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FOREWORD

This final environmental statement was prepared by the U.S. Nuclear Regulatory Commission (NRC), Office of Nuclear Reactor Regulation (the staff), in accordance with the Commission's regulations, set forth in Title 10 of the Code of Federal Regulations, Part 51 (10 CFR 51), which implements the requirements of the National Environmental Policy Act of 1969 (NEPA).

This environmental review deals with the impacts of operation of the Limerick Generating Station, Units 1 and 2. Assessments relating to operation that are presented in this statement augment and update those described in the Final Environmental Statement-Construction Phase (FES-CP) that was issued in November 1973 in support of issuance of construction permits for Limerick Units 1 and 2, by

(1) evaluating changes in facility design and operation that will result in environmental effects of operation (including those that would enhance as well as degrade the environment) different from those projected during the preconstruction review.

(2) reporting the results of relevant new information that has become available since the issuance of the FES-CP.

(3) factoring into the statement new environmental policies and statutes that have a bearing on the licensing action

(4) identifying unresolved environmental issues or surveillance needs that are to be resolved by license conditions.

Introductions (resumes) in appropriate sections of this statement summarize both the extent of updating and the degree to which the staff considers the subject to be adequately reviewed.

Copies of this statement, the FES-CP (1973), the DES-OL (1983) and the DES-OL Supp. 1 (1983) are available for inspection at the Commission's Public Document Room, 1717 H Street NW, Washington, D.C., and at the Pottstown Public Library, Pottstown, Pennsylvania. The documents may be reproduced for a fee at either location. Copies of this statement may be obtained by writing to sources indicated on the inside front cover.

Robert E. Martin is the NRC Project Manager for the environmental review of this project. Should there be any questions regarding the content of this statement, Mr. Martin may be contacted by telephone at (301)492-7000 or by writing to the following address:

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1 INTRODUCTION

The proposed action is the issuance of operating licenses (OLs) to the Philadelphia Electric Company (the applicant) for startup and operation of the Limerick Generating Station, Units 1 and 2, on the banks of the Schuylkill River, south of the borough of Pottstown, Pennsylvania.

The generating system consists of two boiling water reactors, two steam turbine generators, heat-dissipation systems, and associated auxiliary facilities and engineering safeguards. Waste heat will be dissipated to the atmosphere by two natural draft cooling towers, using water from the Schuylkill River and/or Perkiomen Creek, augumented as necessary by water from the Delaware River.

The rated thermal capability of each unit is 3293 MWt (ER-OL* Section 3.2); the design electrical rating is 1055 MWe; and the design thermal (stretch) capability is 3440 MWt (ER-OL Section 3.2).

The Draft Environmental Statement for the environmental review of the Limerick Generating Station (LGS) Units 1 and 2 at the operating license stage was issued as NUREG-0974 in June 1983. That report did not include an assessment of the environmental impact of postulated severe accidents (e.g., Sections 5.9.4 and 6.4) because the staff's review of this subject was still under way at that time. Subsequently the staff's review of the environmental impact of postulated severe accidents for the LGS operating license review has been completed, and was included in Supplement No. 1 to the DES issued in Decemeber 1983. These results were reported in Section 5.9.4, updated Sections 6 and 7, and additional Appendices H, I, J, K, L, M, and N.

1.1 Administrative History

On February 26, 1970, Philadelphia Electric Company filed an application with the Atomic Energy Commission (AEC), now the Nuclear Regulatory Commission (NRC), for permits to construct Limerick Generating Station, Units 1 and 2. The conclusions resulting from the AEC staff's environmental review were issued as a Final Environmental Statement-Construction Phase (FES-CP) in November 1973. Following reviews by the AEC regulatory staff and its Advisory Committee on Reactor Safeguards (ACRS), public hearings were held before an Atomic Safety and Licensing Board (ASLB). Construction permits for Units 1 and 2 were issued on June 19, 1974.

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*"Limerick Generating Station, Units 1 & 2 Environmental Report, Operating License Stage," issued by Philadelphia Electric Company in March 1981. Hereinafter this document is cited in the body of the text as ER-OL, usually followed by a specific section, page, figure, or table number. The "Final Safety Analysis Report" issued by Philadelphia Electric Company is similarly cited herein as FSAR, followed by the section, paragraph, figure, or table number.

On May 6, 1980, the staff requested the applicant to conduct a risk assessment of the Limerick facility. The purpose of the request included the evaluation of high population densities and proposed power levels on severe accident consequences.

On March 17, 1981, the applicant submitted applications for OLs for Limerick Units 1 and 2. The OL application was docketed on July 27, 1981. The OL application included the Environmental Report (ER-OL). The OL application was also accompanied by a probabilistic risk assessment (PRA) that addressed consequences of accident sequences initiated by causes internal to the plant systems ("internal events"). The ER-OL referenced the PRA in response to staff questions on the NRC Statement of Interim Policy on Nuclear Power Plant Accident Conditions under the National Environmental Policy Act of 1969 (45 FR 40101). Subsequently, in Revision 12 to the ER-OL issued in April 1983, the applicant replaced this reference with a reference to a severe accident risk assessment (SARA) that complemented the earlier PRA by also addressing the consequences of accident sequences initiated by causes external to the plant systems ("external events"). The SARA was provided to the staff by submittals dated April 21, July 1, and July 15, 1983. The staff reviewed these submittals to assess the environmental impact of postulated severe accidents for the LGS (Section 5.9.4).

This report documents the staff's use of PRA in its inquiry into the environmental impacts of reactor accidents. The staff's inquiry into the implications of the risk assessments for reactor design and operation; to wit, questions of compliance with the reactor safety regulations and the questions of whether plant-specific vulnerabilities to severe accidents warrant requirements more stringent than the norm, will be documented elsewhere.

The applicant estimates that Unit 1 will be ready for fuel loading in August 1984.

1.2 Permits and Licenses

The applicant has provided in Section 12 of the ER-OL a status listing, as of March 1984, of environmentally related permits, approvals, and licenses required from Federal and state agencies in connection with the proposed project. The NRC staff has reviewed the listing and the current status of those approvals listed as not received.

The issuance of a water quality certification, or waiver therefrom, pursuant to Section 401 of the Clean Water Act of 1977 by the Commonwealth of Pennsylvania is a necessary prerequisite for the issuance of an operating license by the Nuclear Regulatory Commission. This certification was received by the applicant on December 13, 1973.

The Pennsylvania Department of Environmental Resources (DER) has received authority to administer the National Pollutant Discharge Elimination System (NPDES) program in Pennsylvania. The applicant has submitted an NPDES permit application to the DER for the plant operating discharges in August 1983. Regulations or policies and procedures for the NPDES under the Clean Water Act require that application for an NPDES permit be submitted to the permitting agency no later than 180 days in advance of the date on which the discharge is to begin, unless permission for a later application date has been granted by the permitting agency. Because the estimated fuel load date for Unit 1 is August 1984, with operation--and hence, pollutant discharge--following, the staff believes that the application schedule as mentioned above will not preclude the receipt of an NPDES permit by the applicant before the anticipated date when pollutant discharge is to begin.

1.3 Commission Policies and Positions on the Post-TMI Treatment of Severe Accident Consequences in Environmental Impact Statements

The March 28, 1979 accident at the Three Mile Island nuclear plant emphasized the need for changes in NRC policies regarding the considerations to be given to serious accidents from an environmental as well as a safety point of view. With this realization, the Commission issued on June 13, 1980 (45 FR 40101) a Statement of Interim Policy on Nuclear Power Plant Accident Considerations Under The National Environmental Policy Act of 1969. Some of the key positions presented in this policy statement include:

- It is the position of the Commission that its Environmental Impact Statements, pursuant to Section 102(C)(i) of the National Environmental Policy Act of 1969, shall include a reasoned consideration of the environmental risks (impacts) attributable to accidents at the particular facility or facilities within the scope of each such statement. In the analysis and discussion of such risks, approximately equal attention shall be given to the probability of occurrence of releases and to the environmental consequences of those releases.

- The extent to which events arising from causes external to the plant which are considered possible contributors to the risk associated with the particular plant shall also be discussed. Detailed quantitative considerations that form the basis of probabilistic estimates of releases need not be incorporated in the Environmental Impact Statements but shall be referenced herein. Such references shall include, as applicable, reports on safety evaluations.

- The environmental consequences of releases whose probability of occurence has been estimated shall also be discussed in probabilistic terms. Such consequences shall be characterized in terms of potential radiological exposures to individuals, to population groups, and, where applicable, to biota.

- Health and safety risks that may be associated with exposures to people shall be discussed in a manner that fairly reflects the current state of knowledge regarding such risks. Socioeconomic impacts that might be associated with emergency measures during or following an accident should also be discussed. The environmental risk of accidents should also be compared to and contrasted with radiological risks associated with normal and anticipated operational releases.

- In promulgating this interim guidance, the Commission is aware that there are and will likely remain for some time to come many uncertainties in the application of risk assessment methods, and it expects that its Environmental Impact Statements will identify major uncertainties in its probabilistic estimates. On the other hand the Commission believes that the state of the art is sufficiently advanced that a beginning should now be made in the use of these methodologies in the regulatory process, and that such use will represent a constructive and rational forward step in the discharge of its responsibilities.

In addition the staff wishes to emphasize its view that probabilistic risk assessment (PRA) is only one of several tools to be used in making backfit decisions for plants already licensed and in developing safety rulemaking for future standardized designs. We also caution that although we intend to encourage broad uses of the PRA methodology in regulatory decisionmaking--including severe accident analysis in operating nuclear power plants--we do not expect to develop widespread requirements for compliance with any numerical safety goal design objectives that might be approved for individual licensing reviews until requirements in PRA methodology make it more appropriate for this purpose.

In keeping with the above view, the analysis of severe accident consequences in this document has a number of unique features that enhance its value for gaining insight into the uses and limitations of PRA in assessing environmental consequences: (i) the Limerick PRAs are the only large-scale PRAs thus far available for comtemporary BWRs that include external events as potential accident initiators; (ii) the site is substantially higher than average in terms of population density; and (iii) very few OL reviews can be anticipated to have available a large-scale PRA. Accordingly, much more information is available in the case of Limerick for the assessment of severe accident consequences than has been customary in environmental impact statements for other OL actions and, by the same token, this has led to an expanded scope of analysis consistent with the Statement of Interim Policy that should not be expected for other OLs.

Although the scope of this document should be regarded as unique but not precedent setting, a number of cautionary notes are needed to place its purposes and limitations into clear perspective:

- A principal purpose of its discussion of severe accident consequences is to achieve full disclosure of relevant information in keeping with the intent and spirit of NEPA.

- The comparisons of severe accident risk in this document provide an approximate indication of risk at Limerick compared with other nuclear plants, along with an indication of the uncertainty in the calculations. Because of the uncertainties, the numbers and conclusions derived therefrom are not to be regarded as the sole basis for arriving at decisions on severe accident prevention, mitigation and management. The staff also is evaluating the PRA for the insight it provides concerning dominant contributors to risk to supplement the deterministic judgements provided in NRC traditional safety areas.

In summary, the analysis of severe accident consequences presented in this document must be interpreted with the above purposes and caveats in mind. The staff feels that the disclosure of this information supports both the intent of NEPA as well as that of the Commission to encourage broad uses of PRA methodology, including assessment of risks at high population density sites, as a constructive and rational forward step.

2 PURPOSE AND NEED FOR THE ACTION

The Commission has amended 10 CFR 51, "Licensing and Regulatory Policy and Procedures for Environmental Protection," effective April 26, 1982, to provide that need for power issues will not be considered in ongoing and future operating license proceedings for nuclear power plants unless a showing of "special circumstances" is made under 10 CFR 2.758 or the Commission otherwise so requires (47 FR 12940, March 26, 1982). Need for power issues need not be addressed by operating license applicants in environmental reports to the NRC, nor by the NRC staff in environmental impact statements prepared in connection with operating license applications (10 CFR 51.21, 51.23(e), and 51.53(c)).

This policy has been determined by the Commission to be justified even in situations where, because of reduced capacity requirements on the applicant's system, the additional capacity to be provided by the nuclear facility is not needed to meet the applicant's load responsibility. The Commission has taken this action because the issue of need for power is correctly considered at the construction permit (CP) stage of the regulatory review where a finding of insufficient need could factor into denial of issuance of a license. At the OL review stage, the proposed plant is substantially constructed and a finding of insufficient need would not, in itself, result in denial of the operating license.

Prior discussions in the DES and DES Supplement 1 did consider the savings associated with the nuclear plant as compared to alternative energy sources. Consistent with the Commission's regulations in 10 CFR Parts 51.21 and 51.23(e), these discussions are no longer included in this document. These discussions specifically assess fossil fuels as alternatives to the proposed Limerick nuclear power unit. Costs associated with replacement power as an element of economic risk of severe accidents, however, are considered in Section 5.9.4.5 inasmuch as it is not a consideration of alternate energy sources for the operation of the Limerick facility, instead, assesses the economic loss resulting from the need to replace lost power capability with capacity from fossil units existing at that time.

2.1 References

U.S. Nuclear Regulatory Commission, "Need for Power and Alternative Energy Issues in Operating License Proceedings," proposed rule, Federal Register, 46 FR 39440, August 3, 1981.

---, "Need for Power and Alternative Energy Issues in Operating License Proceedings," final rule, Federal Register, 47 FR 12940, March 26, 1982.

3 ALTERNATIVES TO THE PROPOSED ACTION

The Commission has amended its regulations in 10 CFR 51 effective April 26, 1982, to provide that issues related to alternative energy sources will not be considered in operating license proceedings for nuclear power plants unless a showing of special circumstances is made under 10 CFR 2.758 or the Commission otherwise so requires (47 FR 12940, March 26, 1982). In addition, these issues need not be addressed by operating license applicants in environmental reports to the NRC, nor by the NRC staff in environmental impact statements prepared in connection with operating license applications (see 10 CFR 51.21, 51.23(e), and 51.53(c)).

The Commission has concluded that alternative energy source issues are resolved at the CP stage, and the CP is granted only after a finding that, on balance, no superior alternative to the proposed nuclear facility exists. By earlier amendment (46 FR 28630, May 28, 1981), the Commission also stated that alternative sites will not be considered at the operating license stage, except under special circumstances, in accordance with 10 CFR 2.758. Accordingly, this statement does not consider alternative energy sources or alternative sites.

3.1 References

U.S. Nuclear Regulatory Commission, "Alternative Site Issues in Operating License Proceedings," final rule, Federal Register, 46 FR 28630, May 28, 1981.

---, "Need for Power and Alternative Energy Issues in Operating License Proceedings," final rule, Federal Register, 46 FR 12940, March 26, 1982.

4 PROJECT DESCRIPTION AND AFFECTED ENVIRONMENT

4.1 Résumé

This résumé highlights changes in the plant operating characteristics and design as well as new information on the local environment obtained since the FES-CP was issued in 1973.

The only change to the general description of the plant layout is the addition of a two-story technical support center building (see Section 4.2.1). Volumetric flow rates for the various systems have been revised, as discussed in Section 4.2.3.2 of this statement. The biocide treatment scheme of the cooling water has been changed and is addressed in Section 4.2.3.4. The changes made in the cooling system are discussed in Section 4.2.4. The changes in the volume and character of nonradioactive effluents since the FES-CP was issued are addressed in Section 4.2.6. There also have been changes in the power transmission system, such as the addition of two new lines (see Section 4.2.7).

New information and updated information on surface water are provided in Section 4.3.1. Updated water quality data are given in Section 4.3.2; new information on severe weather and site atmospheric dispersion characteristics is provided in Section 4.3.3, and revised descriptions of terrestrial and aquatic resources are in Section 4.3.4. Section 4.3.7 gives the updated information on historic and archaeologic sites.

4.2 Facility Description

4.2.1 External Appearance and Plant Layout

A general description of the plant layout and external appearance is in the FES-CP (Section 3). The only change to that description is the addition of a two-story Technical Support Center building south of the Unit 2 cooling tower and east of the water treatment enclosure. The building contains approximately 2230 m^2 (24,000 ft^2) of floor area and is designed to be consistent in style with other buildings at the site (ER-OL response to NRC staff question 310.1). A site layout map, Figure 4.1, shows the location of the significant structures.

4.2.2 Land Use

A description of regional land use is in Section 2.2.2.1 of the FES-CP. Updated information on land use, based on a 1976 survey, is in Section 2.1.3.4 of the ER-OL. In general, the area within 8.1 km (5 miles) of the site is comprised predominantly of the following land use types: miscellaneous (mostly abandoned farm lands and open space) - 50.7%; agricultural - 21.9%; residential - 13.3%; and industrial - 7.8% (ER-OL Table 2.1-18). This composition is expected to change over the next 20 years, reflecting greater residential use and a decline in agricultural use.

Agricultural use within 8.1 km (5 miles) of the site has been mainly small dairy farms. More than 90% of the agricultural land is used for crop production and

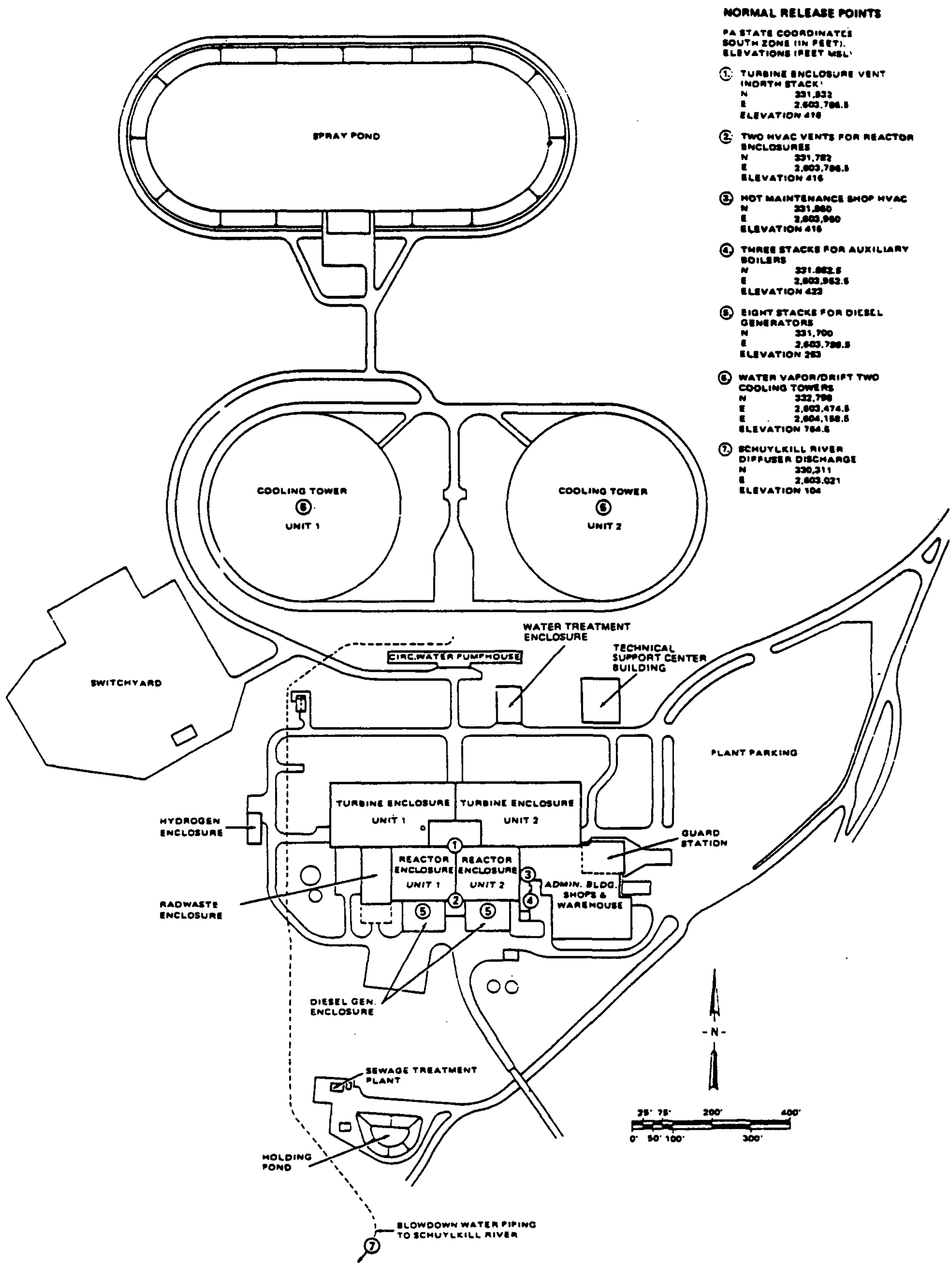

Figure 4.1 Plot plan and normal release point for effluents

pasture. Beef farming and hog farming also are important in the site vicinity. Locations of cattle and hog farms, by distance and compass direction from the Limerick station, are in ER-OL Table 2.1-25.

The General Assembly of the Commonwealth of Pennsylvania by an Act (No. 1978-333) declared that portion of the Schuylkill River from Douglassville (Bridge) to Norristown Dam, a distance of 34.2 river miles, to be classified as modified recreational. Section 6 of the Act states: "An act encouraging landowners to make land and water areas available to the public for recreational purposes... shall be applicable to owners of land and water areas within the Schuylkill scenic river component...."

4.2.3 Water Use and Treatment

4.2.3.1 General

The overall water use scheme of Limerick generating station has not changed since the FES-CP was issued. The station is equipped with a closed cycle cooling system that uses natural draft cooling towers for heat rejection in the condenser circulating water system and in the service water system during normal operation. The cooling towers or an onsite spray pond will be utilized for heat rejection by the residual heat removal and emergency service water system during shutdowns and during other-than-normal operation. The spray pond would be used only if the station cooling towers were not available.

The water supply for Limerick remains as indicated in the FES-CP. The Schuylkill River will be the primary source of water for the station, with supplementation from the Delaware River and Perkiomen Creek, via the Point Pleasant Diversion system, when Delaware River Basin Commission constraints prohibit withdrawal from the Schuylkill River. The Schuylkill River will receive all liquid station discharges.

4.2.3.2 Surface Water Use

The volumetric flow rates for the various water systems for Limerick have been revised since the FES-CP was issued because the specific design of the station's water use systems, not complete at that time, now is complete.

Water to Limerick for consumptive use is expected to be derived from three sources, in the following proportions, on an annual basis:

Schuylkill River - 50%
Perkiomen Creek - 4%
Delaware River - 46%

Water for nonconsumptive use will be supplied by the Schuylkill River. Restrictions on consumptive water use have been set by the Delaware River Basin Commission (DRBC) (DRBC, 1973; DRBC 1975). The specific terms of the restrictions are given in the applicant's ER-OL Appendix 2.4A. Based on historical flow records, the applicant anticipates that virtually all of the water supplied to Limerick to replace consumptive losses (i.e., evaporation and drift) during the period June through October of an average year will come from the Delaware River/Perkiomen Creek system because of the DRBC restrictions. During the remainder of the year, the applicant anticipates that there will be no use of these waters by Limerick.

The average Limerick makeup water flow rate for full power operation of two units, on an annual basis, is estimated to be 2.1 m^3/sec (72.9 ft^3/sec), nearly identical to the value of 2.1 m^3/sec (74 ft^3/sec) given in the FES-CP. The range of values and average values for the June-to-October Point Pleasant Diversion use period and for the remainder of the year, as well as for an overall annual period, is given for the Schuylkill River and for the Perkiomen Creek/Delaware River system in Table 4.1. A schematic diagram of plant water use is shown in Figure 4.2.

Table 4.1 Average water use during two-unit full-power operation, ft^3/sec*

Use	Range	Average
Makeup		
Schuylkill River		
Annual	22.4-76.9	49.7
June through October	22.4-24.8	24.0
Remainder of year	63.1-76.9	68.0
Delaware River/Perkiomen Creek		
Annual	0-57.4	23.2
June through October	52.2-57.4	55.7
Remainder of year	0	0
Evaporation		
Annual	43.3-56.6	50.1
June through October	51.4-56.6	54.9
Remainder of year	43.3-52.9	46.7
Drift		
Annual	-	0.6
Spray Pond Seepage and Evaporation		
Annual	-	0.2
Blowdown		
Annual	19.0-24.8	22.0
June through October	22.4-24.8	24.0
Remainder of year	19.0-23.2	20.5

*To convert ft^3/sec to m^3/sec, multiply values shown by 0.028.

Source: ER-OL Table 3.3-1

The average consumptive use of water is estimated to amount to about 1.4 m^3/sec (50.7 ft^3/sec), compared to an estimated 1.5 m^3/sec (54 ft^3/sec) in the FES-CP.

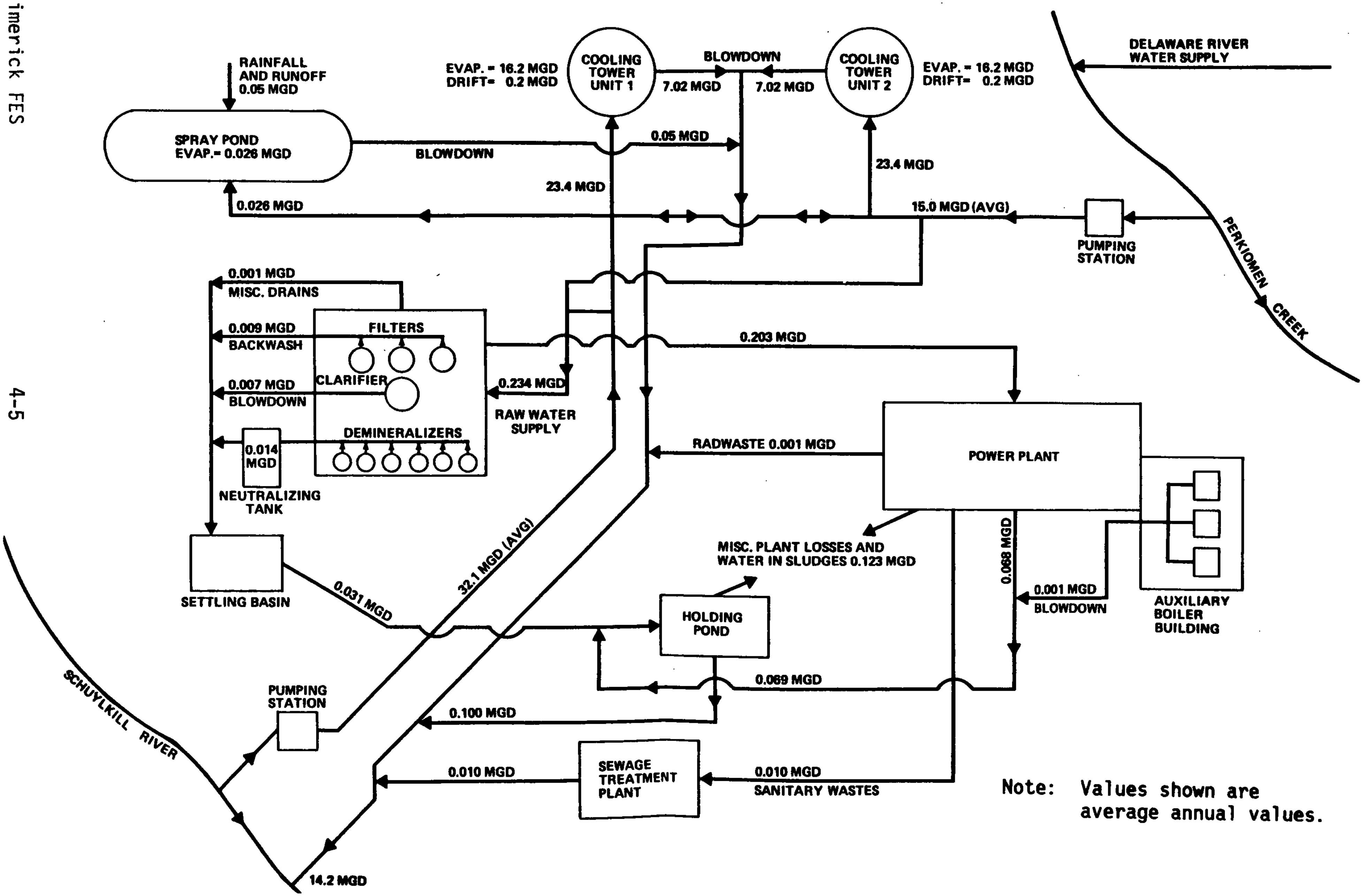

Figure 4.2 Schematic of water use during plant operation
Source: ER-OL Figure 3.3-1

The majority of this use occurs through evaporation in the station's cooling towers. The remainder occurs through drift loss from the towers. This amount is estimated to occur at a rate of 1.8×10^{-2} m^3/sec (0.6 ft^3/sec), based on a 0.03% of the cooling tower water flow rate loss, as observed from operating cooling towers of this type and manufacture (response to staff question E291.7). The loss rate estimated by the staff in the FES-CP was 0.003%, or 8.5×10^{-4} m^3/sec (0.03 ft^3/sec). The revised estimate, based on observed operating experience, however, is higher than values estimated for other nuclear plants with large natural draft cooling towers.

Station liquid discharge to the Schuylkill River is primarily (about 99%) cooling tower blowdown and is estimated to average 0.6 m^3/sec (22.0 ft^3/sec), identical to the estimated value in the FES-CP.

At 100% station load, the water use rates given above represent an average concentration factor of about 3.4. The anticipated concentration factor given in the FES-CP was 3.7.

The station essential service water will be supplied by an onsite spray pond. The spray pond has a surface area of 3.9 ha (9.6 acres). The pond is lined to reduce seepage. When the pond is in use, pond water losses from all sources (seepage, evaporation, drift loss and fuel pool makeup) are expected not to exceed 6.5×10^7 l (17.3×10^6 gal) over a 30-day use period. Normally, the pond will not be in operation. Evaporation and seepage losses during this time are not expected to exceed about 5.7×10^{-3} m^3/sec (0.2 ft^3/sec). Makeup water to compensate for these losses will be supplied from the Schuylkill River intake structure or from either cooling tower basin. Excess waterflow into the pond because of rainfall is projected to average 2.3×10^{-3} m^3/sec (0.08 ft^3/sec), based on the average annual site rainfall. Overflow from the pond will be discharged to the Schuylkill River in the station blowdown.

4.2.3.3 Groundwater Use

There is no planned use of groundwater by Limerick during its operation.

4.2.3.4 Water Treatment

Both the circulating and service water cooling systems and the makeup water system will utilize water treated in some way. Thus, virtually all water used at Limerick will be treated in some way before or during its station use.

The circulating water system, serving the cooling tower/condenser system, will be treated with sulfuric acid for the control of scale in the system, as proposed in the FES-CP. The amount of acid used to reduce calcium carbonate scale is less than that proposed in the FES-CP: about 3175 kg/day/unit (3.5 T/day/unit) is the presently estimated average usage rate, compared to about 5910 kg/day/unit (6.5 T/day/unit) estimated in the FES-CP. No corrosion inhibitors are planned for use in the circulating or service water systems that are connected to the Limerick blowdown line. Because the service water is mixed with the station circulating water in the cooling towers, this scaling control scheme will treat both systems.

The only other cooling water treatment is the intermittent addition of chlorine as a biocide at Limerick (i.e., cooling water delivered to the station via the

Point Pleasant Diversion System will not be chlorinated before its use at the power station). The biocide treatment scheme has changed since the issuance of the FES-CP. Chlorination of the station main condensers is scheduled for six 20-minute periods per day per unit (120 min/day/unit). The application duration and frequency given in the FES-CP was twice a day for up to 60 minutes duration for each application (up to 120 min/day/unit). The anticipated application requirement is 2 mg/l to maintain a measurable free available chlorine (FAC) residual at the condenser outlet. The target FAC concentration at this location is about 1.0 mg/l (response to the NRC staff question E291.11). The condenser outlet FAC concentration target given in the FES-CP was 0.2 mg/l. The corresponding average estimated usage rate of biocide is 412 kg/day/unit (0.45 T/day/unit). The biocide application point for the condenser system is the cooling tower basin outlets. There are two outlets from each cooling tower serving a single unit's main condenser. Only one condenser feed line is chlorinated at a time, so that only half the condenser is shock treated at a time. This differs from the proposal in the FES-CP, which was to treat the entire condenser during each chlorination. The condenser circulating water feed lines are further split at the condenser inlet, providing four feed lines through the main condenser. These lines are recombined in an alternate manner downstream of the condensers so that each half of the condenser feed line from the cooling tower outlet that is chlorinated is combined with a half of the other condenser feed line that was not chlorinated. The chlorinated and unchlorinated circulating waters are mixed before the water returns to the cooling tower.

The applicant currently estimates a need to shock chlorinate the cooling tower portion of the circulating water system to control biological growths in the tower fill sections. When the FES-CP was issued, such treatments were not considered needed. Cooling tower treatment frequency is estimated to be three to four times a year, with a target concentration of up to 10 mg/l FAC, as measured in the cooling tower basin.

Separate treatment of the Limerick service water system for scale or biofouling control is not provided for during normal operation because the water supplied to this system is taken from and returned to the cooling tower basins and cooling tower fill ring, respectively. The treatments applied to the circulating water are expected to be sufficient to treat the service water system as well (response to IE Bulletin 81-03).

During other-than-normal operating conditions, the service water system will be supplied by the onsite emergency spray pond. Treatment of this pond with hypochlorite to control algal growth is anticipated to be necessary about twice a year. The target FAC concentration is 0.5 mg/l.

Other water used at Limerick is treated in either the makeup water treatment facility or in the raw water treatment facility. These systems will supply clarified, filtered, disinfected, or demineralized water, as appropriate, to the various station uses within the station, such as the circulating water pump seal system, the domestic water system, and the demineralized water system. Alum, polyelectrolyte, sodium hydroxide, and hypochlorite will be used for clarification. Sodium hydroxide and sulfuric acid will be used to regenerate the demineralizers. Expected chemical usage, as provided by the applicant, is shown in Table 4.2.

Table 4.2 Chemical usage resulting in discharge during two-unit operation

Chemical usage, tons/yr*	Max.**	Avg.	Purpose of usage
Sulfuric acid	4000	2000	Cooling water scaling control Makeup demineralizer regeneration Holding pond pH adjustment
Sodium hydroxide	60	30	Makeup demineralizer regeneration Clarifed water neutralization Holding pond pH adjustment
Aluminum sulfate	20	10	Clarified water coagulation Holding pond coagulation
Polyelectrolyte	2	1	Clarified water coagulation aid Holding pond coagulation aid
Chlorine gas	600	300	Cooling water biological control
Hypochlorite	2	1	Clarified water disinfection Domestic water disinfection Treated sewage disinfection Spray pond biological control
Sodium sulfite	2	1	Auxiliary boiler corrosion control
Trisodium phosphate	2	1	Auxiliary boiler scaling control
			Turbine enclosure cooling water conditioning Admin HVAC cooling water conditioning Containment str chilled water conditioning
Fluoroprotein (National Area-O-Form)	2	1	Fire protection system tests and use
Detergents	2	1	Laundry and personnel showers

*Other chemicals are used but are treated by demineralization or evaporation in the radwaste; 1 short ton = 0.9072 metric ton.
**The maximum is not expected to exceed twice the average.

Source: ER-OL Table 3.6.1

4.2.4 Cooling System*

Limerick will utilize a closed-cycle recirculating cooling system with two natural draft hyperbolic cooling towers, one per unit. The Schuylkill River serves as the primary source and receiving waters for the operation of Limerick. Under conditions imposed by the DRBC (DRBC, 1975), water for consumptive use by Limerick may be withdrawn from the Schuylkill River only when river flows at the Pottstown gage exceed 530 ft^3/s (237,880 gpm) with one unit operating, or 560 ft^3/s (251,345 gpm) with two units operating, or when the downstream river water temperature is not greater than 15°C (see Sections 4.2.3, 4.3.1.2, and 4.3.2.2). When river water temperature is greater than 15°C water may be withdrawn from the Schuylkill River during April, May, and June when river flow is greater than 1791 ft^3/sec (802,368 gpm). When flows are less than these minima, cooling water will be supplemented by water withdrawn from the Delaware River at Point Pleasant and transported to Limerick through the East Branch of Perkiomen Creek and into the Main Stem of Perkiomen Creek where it will be withdrawn at Graterford and piped to the power station (Figure 4.2).

Several changes have been made in the designs and locations of the various cooling system structures since the FES-CP was issued. These are discussed individually below.

<u>Schuylkill River - Intake</u>

The makeup water pumping station is located along the eastern shore of the river at km 77.56, opposite the northern tip of Limerick Island. Water will be withdrawn from the east river channel at a rate of about 77 ft^3/s (34,000 gpm) during normal full power operation. The pumping structure has a maximum capacity of 94 ft^3/s (42,000 gpm). The pumphouse contains four bays and four vertical traveling screens that are 1.5 m (5 feet) wide with 6.4-mm (0.25-inch) mesh openings. Trash racks with 88.9-mm (3.5-inch) openings between bars are provided in front of the intake to protect the screens, and in both the upstream and downstream ends of the structure to permit free passage of fish swimming near the screen face. A floating trash boom in front of the trash racks will divert most surface debris and some organisms before they reach the trash racks.

At average river level and pump flow, the average approach velocity to the screens is less than 15.2 cm/s (0.5 fps). At low river level and maximum pump flow, the approach velocity is less than about 18.6 cm/s (0.61 fps). Screen wash can be actuated either by an automatic timer at regular intervals (a 15-minute wash once every 4 hours) or by a pressure differential across the screens. Debris gathered from the trash racks and debris and organisms impinged on the traveling screens are disposed of off site (ER-OL Section 3.4.5).

The intake design reviewed in the FES-CP and the ASLB Initial Decision of June 14, 1974 (LBP-74-44) included: (1) the use of two shoreline intake structures (rather than the one structure presently proposed), and (2) a maximum approach velocity at the traveling screens of 22.9 cm/s (0.75 fps) at maximum

*For the data in the following sections, to change ft^3 to m^3, multiply the values shown by 0.0283; to change gallons to liters, multiply the values shown by 3.7854.

pump flow and low river level (compared with 18.6 cm (0.61 fps) presently). These are the major design differences from that reviewed at the CP stage.

Schuylkill River - Discharge

Nonconsumptive water and cooling tower blowdown is returned to the river (at km 77.24) through a 43-m (141-foot) long discharge diffuser consisting of a 71-cm (28-inch) steel pipe with 283 nozzles of 3.2-cm (1.25-inch) diameter installed on 15.2-cm (6-inch) centers. The diffuser is encased in a concrete channel stabilization structure that runs from the east river bank across the east channel to the southern tip of Limerick Island and then across the west channel to the west river bank. The effluent thus enters the river at the southern tip of Limerick Island where the east and west channels converge. It is estimated that one-half to one-third of the river flow will pass over the diffuser.

The normal effluent flow rate is estimated to average about 22 ft^3/s (14.2 mgd), with a normal maximum of about 26 ft^3/s (17 mgd). Discharge velocity will be 2.7 to 3.4 m/s (9 to 11 fps). Estimated monthly average discharge temperatures are expected to range beween about 3 to 18°C above ambient, with an average of about 11°C. The mixing zone is expected to extend downstream of the diffuser to a distance between ~9 to 46 m (30 to 150 feet), with an area between 404.6 to 2020 m^2 to (0.1 to 0.5 acres). During average water level conditions, the mixing zone will extend from about the southern tip of Limerick Island to the east river bank. The west channel will be unaffected (Figure 4.3) (ER-Sections 3.4.5, 5.1.2, and 5.1.3).

The discharge design reviewed in the FES-CP consisted of: (1) a diffuser located about 100 m downstream of the channel stabilization structure; (2) a 76-cm (30-inch) diameter delivery pipe with 400 nozzleholes of 2.5-cm (1-inch) diameter on 7.6-cm (3-inch) centers; (3) a blowdown rate of about 20 m^3/s (12.9 mgd); and (4) an average exit velocity of 2.8 m/s (9.2 fps). Actual discharge temperature above ambient and mixing zone sizes were not specified, other than to state that the DRBC-allowable mixing zone (46 m (150 feet) wide by 1067 m (3500 feet) long with a 2.8°C (5°F) temperature at the edge of the zone) would not be violated.

Delaware River - Intake

The Point Pleasant Diversion is located at river km 253 (river mile 157.2), about 244 m (800 feet) downstream of the mouth of Tohickon Creek, along the Pennsylvania shore (NRC ASLB, 1983). The pumping station is being constructed by Neshaminy Water Resources Authority for water supply purposes. Philadelphia Electric Company is contributing to the project so water can be diverted to Limerick for cooling purposes when Schuylkill River water is not available for consumptive use (Penna, 1982). The maximum withdrawal rate will be 147 ft^3/s (95 mgd), of which a maximum of 71 ft^3/s (46 mgd), or 48%, will be diverted to Limerick (see Section 4.3.1.3 for detail on flow and limitations).

The intake will consist of an array of cylindrical wedge-wire screens placed in the river about 75 m (245 feet) from the Pennsylvania shore. The bottom of the screens will be 0.6 m (2 feet) above the river bottom, and the top of the screens will have a minimum submergence of 1.2 m (4 feet) during low river flows. A total of 12 screens will be used in two rows of 6 screens each, placed end to end. The screens will be ~1 m (40 inches) in diameter with a slot mesh of 2 mm.

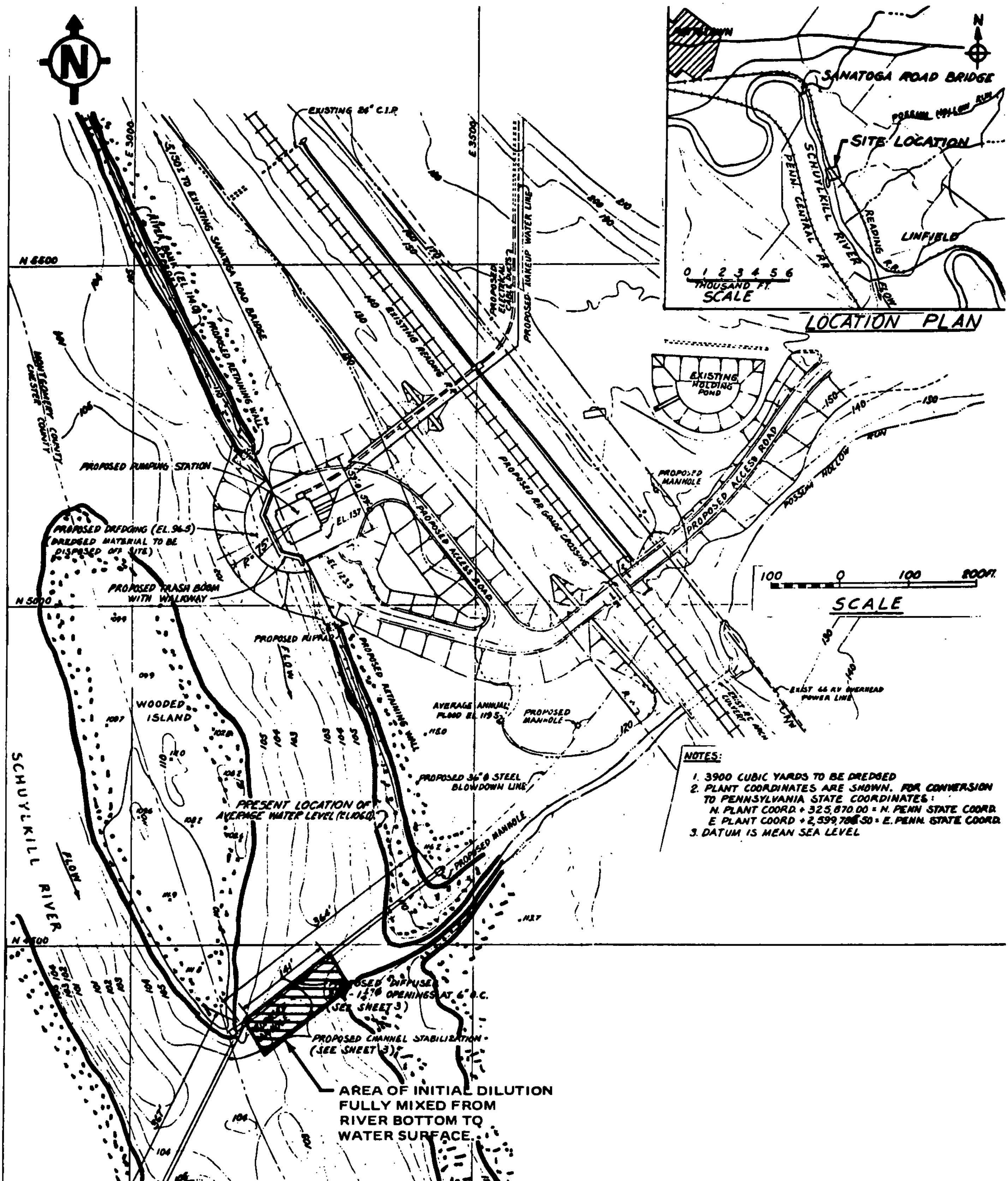

Figure 4.3 Initial dilution area of diffuser discharge

Water will flow through the screens around their total circumference at an average intake velocity of 10.7 cm/s (0.35 fps), with a maximum of 12.4 cm/s (0.5 fps). At a distance of about 0.3 m (1 foot) from the screen, the velocity will be about 2.2 cm/s (0.071 fps). The intake will be provided with an air backwash system to clean debris from the screens. This backwash system will be operated about once a week, except during times of leaf litter when it will be operated once or twice a day (NRC ASLB, 1983).

The diversion intake proposed and reviewed at the CP stage consisted of a shoreline structure with vertical traveling screens and an intake canal that projected about 46 m (150 feet) into the Delaware River (DRBC, 1973). The present wedge-wire screen proposal represents the latest state-of-the-art intake technology compared with that proposed at the CP stage (NRC ASLB, 1983).

East Branch of Perkiomen Creek - Diversion Inflow and Water Transport

Water that is withdrawn from the Delaware River at Point Pleasant will be pumped via pipeline for about 3.9 km (2.4 miles) to Bradshaw Reservoir. From the reservoir, water will be conveyed via pipeline for 10.8 km (6.7 miles) along an existing gas pipeline right-of-way to the upper section of the East Branch of Perkiomen Creek. Water will discharge into the creek at about km 35.7 via an energy dissipater and outlet channel. Riprap will be placed upstream and downstream of the channel on both sides of the creek to reduce erosion of the creek bed and banks (see ER-OL Figure E 291.20-1 and Section 5.3.3.3 of this report). The diversion water will travel through the creek for about 35.7 km (22.2 miles) to the Main Stem of Perkiomen Creek where it can be withdrawn at Graterford for use by Limerick (Penna, 1982) (see Figure 4.2). Pursuant to conditions imposed by the DRBC, once water transport from the Delaware River to Limerick begins, a flow of not less than 27 ft^3/s (17.4 mgd) must be maintained throughout the low flow season, and a minimum flow of 10 ft^3/s (6.5 mgd) must be maintained for the rest of the year (Section 4.3.2.2). The design and plan for water transport through the East Branch to Limerick are essentially unchanged since the CP stage.

The upper creek section (upstream of Sellersville) will be more affected by diversion inflow than will the middle and lower sections during the summer and fall lower flow period. During periods of average inflow pumping to the East Branch, the median flow in the upper section will be increased 4 to 25 times; the median depth will increase 2 to 4.5 times; and the median water velocity will increase 2 to 4 times (DRBC, 1980).

Main Stem of Perkiomen Creek Intake

Water diverted from the Delaware River through the East Branch will enter Perkiomen Creek at about km 18 and be withdrawn downstream at Graterford at km 14.4. The intake consists of a series of submerged stationary wedge-wire screens placed in the creek at midstream. The bottom of the screen will be about 17.8 cm (7 inches) above the creek bottom, and the top will be about 17.8 cm submerged during low creek flows. The screens are cylindrical, approximately 1.8 m (6 feet) long and 0.6 m (2 feet) in diameter, with a slot mesh of 2 mm. The average intake velocity will be less than 0.4 fps, and the maximum velocity will be less than 0.5 fps. The screens are in a single row, end-to-end in a series, with the long axis parallel to the creek flow. Cleaning will be provided by an airburst system that is activated manually from a control panel located in the pumphouse.

When both Limerick units are operating, water will be withdrawn by two pumps. Average withdrawal rates will be about 53 ft^3/s (36.2 mgd), and maximum rates will be about 65 ft^3/s (41.9 mgd). During typical flow years, withdrawal from Perkiomen Creek will begin during late April or early May and continue through October or November. During the period of usage, nonconsumptive water will be withdrawn from the Schuylkill River, while consumptive water will be pumped from the Delaware River and ultimately withdrawn from Perkiomen Creek. During the period of water diversion, about 30% of the water needs for Limerick will come from the Schuylkill River and 70% from the diversion and Perkiomen Creek flows (ER-OL Sections 3.3, 3.4.6, and 5.1.3.2). When water is being withdrawn at average rates, (53 ft^3/s), a relatively large portion of water will be withdrawn: 16% of the average flow (279 ft^3/s, April-November) plus diversion; 75% of the 7-day, 10-year low flow (17.7 ft^3/s) plus diversion; and 93.8% of the lowest recorded flow (3.5 ft^3/s) plus diversion. Occasions will arise when water can be withdrawn from Perkiomen Creek without augmentation; at average withdrawal rates under these conditions, a maximum of 26% of the creek flow will be withdrawn.

The Perkiomen Creek intake proposed at the CP stage was similar to that previously proposed for the Schuylkill River: shoreline intake, vertical traveling screens, and maximum approach velocity of 22.9 m^3/s ($\leq$0.75 fps). The present wedge-wire screen proposal represents the latest in state-of-the-art intake technology compared with that proposed at the CP stage.

4.2.5 Radioactive Waste Management System

Under requirements set by 10 CFR 50.34a, an application for a permit to construct a nuclear power reactor must include a preliminary design for equipment to keep levels of radioactive materials in effluents to unrestricted areas as low as is reasonably achievable (ALARA). The term ALARA takes into account the state of technology and the economics of improvements in relation to benefits to the public health and safety and other societal and socioeconomic considerations and in relation to the utilization of nuclear energy in the public interest. Appendix I to 10 CFR 50 provides numerical guidance on radiation dose design objectives for light-water-cooled nuclear power reactors (LWRs) to meet the requirement that radioactive materials in effluents released to unrestricted areas be kept ALARA.

To comply with the requirements of 10 CFR 50.34a, the applicant provided final designs of radwaste systems and effluent control measures for keeping levels of radioactive materials in effluents ALARA within the requirements of Appendix I to 10 CFR 50. In addition, the applicant provided an estimate of the quantity of each principal radionuclide expected to be released annually to unrestricted areas in liquid and gaseous effluents produced during normal reactor operations, including anticipated operational occurrences.

The NRC staff's detailed evaluation of the radwaste systems and the capability of these systems to meet the requirements of Appendix I is presented in Chapter 11 of the staff's Safety Evaluation Report (SER). The quantities of radioactive material that the NRC staff calculates will be released from the plant during normal operations, including anticipated operational occurrences, are presented in Appendix D of this statement, along with examples of the calculated doses to individual members of the public and to the general population resulting from these effluent quantities.

The NRC staff's detailed evaluation of the solid radwaste system and its capability to accommodate the solid wastes expected during normal operations, including anticipated operational occurrences, is in Chapter 11 of the SER. On the basis of its evaluation and recent data from operating boiling water reactors, the NRC staff estimates that approximately 420 m^3 (15,000 ft^3) of "wet solid wastes" containing 6000 Ci of radioactivity (mainly the long-lived fission and corrosion products Co-60 and Cs-137), 850 m^3 (30,000 ft^3) of compacted "dry solid wastes" containing less than 10 Ci of radioactivity, and 710 m^3 (25,000 ft^3) of noncompressible "dry waste" (filters, tools, etc.) will be shipped off site annually to a licensed land disposal site. The packaging and shipping of all these wastes will be in conformance with the applicable requirements of 10 CFR 20, 61, and 71 and 49 CFR 170 to 178.

As part of the operating licenses for this facility, the NRC will require Technical Specifications limiting release rates for radioactive material in liquid and gaseous effluents and requiring routine monitoring and measurement of all principal release points to ensure that the facility operates in conformance with the radiation-dose-design objectives of Appendix I.

4.2.6 Nonradioactive Waste Management Systems

4.2.6.1 General

Nonradioactive effluents will result from the operation of the Limerick evaporative cooling system, the water treatment system, and the wastewater treatment system. There have been changes in the volume and character of these effluents since the FES-CP was issued. These changes are discussed below.

4.2.6.2 Cooling Water Systems

The operation of the closed cycle cooling system for the station will result in the discharge of water of different composition from that either withdrawn from the Schuylkill River or that received from the Point Pleasant Diversion. As indicated in Section 4.2.3 of this report, the evaporative loss from the natural draft cooling towers will result in a concentration of physical and chemical constituents in the makeup water. The expected average concentration of the constituents in the system blowdown as a result of operation of the station cooling water system will average about 3.4 times the intake concentration values (the Limerick makeup and blowdown values predicted for the June-through-October period indicate an average concentration factor for this period of about 3.2). The applicant's estimated seasonal ranges and median values for the constituents of the station discharge are given in Table 4.3. For those cooling water blowdown constituents that are affected by the evaporative process only (i.e., those unaffected by chemical addition or physical processes), the values given in the table are based on the application of the average station concentration factor to a set of simulated intake water quality values (ER-OL Table 3.6-2) that themselves were derived by the applicant by application of the DRBC water appropriation restrictions to the record of flow, temperature, and constituent quality data for the Schuylkill River, the East Branch and Main Stem of Perkiomen Creek, and the Delaware River for the 1975-1978 period. The values given for the remaining blowdown constituents (temperature, pH, biochemical oxygen demand, dissolved oxygen, total alkalinity, ammonia nitrogen, sulfate, nitrate, total phosphate, and orthophosphate) were derived by the applicant after simulation of the effects of temperature change, temperature-induced reaction rate and

Table 4.3 Simulated blowdown water quality from Limerick generating station, 1975 through 1978

PARAMETER	DEC, JAN, FEB			MAR, APR. MAY			JUN, JUL, AUG			SEP, OCT, NOV		
	MIN	MED	MAX	MIN	MED	MAX	MIN	MED	MAX	MIN	MED	MAX
TEMPERATURE (C)	12.2	14.6	18.9	13.9	20.3	26.7	25.4	28.1	31.1	15.4	23.7	28.2
DISSOLVED OXYGEN (mg/l)	8.9	9.6	10.3	6.7	8.2	10.1	4.4	6.4	7.3	6.5	7.5	10.2
BIOCHEMICAL OXYGEN DEMAND (mg/l)	0.6	7.3	9.8	3.3	5.4	13.0	2.5	6.8	12.9	0.0	4.4	11.6
TOTAL ORGANIC CARBON (mg/l)	0.0	4.7	70.7	0.0	27.2	66.3	6.4	29.8	82.3	0.0	8.6	44.4
pH	7.05	7.25	7.71	7.14	7.37	7.90	7.00	7.24	7.78	6.91	7.25	7.72
TOTAL INORGANIC CARBON (mg/l)	142.1	219.9	329.8	98.6	195.1	304.9	72.8	234.1	278.9	136.4	232.8	373.6
TOTAL ALKALINITY (mg/l)	136.5	211.5	279.4	95.6	182.0	263.3	71.9	210.3	256.1	131.7	222.0	291.3
FREE CARBON DIOXIDE (mg/l)	3.7	8.5	17.0	2.0	7.4	12.9	0.4	4.4	20.0	2.3	8.8	22.4
TOTAL HARDNESS (mg/l)	278.3	431.4	721.4	246.5	390.3	609.9	277.7	379.6	491.9	201.6	438.8	782.6
SPECIFIC CONDUCTANCE (µsm/cm)	734	1087	1605	583	942	1533	706	1014	1228	709	1096	1717
TURBIDITY (JTU)	11.9	27.2	71.4	10.2	23.8	578.0	7.3	24.8	806.3	2.9	22.1	80.8
TOTAL SUSPENDED SOLIDS (mg/l)	3	34	126	3	30	1282	9	44	770	1	24	160
TOTAL DISSOLVED SOLIDS (mg/l)	58	731	1017	109	598	1057	565	752	898	468	758	1136
CHLORIDE (mg/l)	38.42	70.38	127.63	27.57	58.10	135.32	50.65	72.28	151.17	35.02	89.35	134.98
FLUORIDE (mg/l)	0.03	0.51	1.05	0.00	0.47	1.47	0.12	0.82	1.53	0.20	0.81	1.14
SULFATE (mg/l)	149.90	281.5	478.8	118.3	196.4	367.2	150.1	187.6	262.4	107.5	228.6	616.7
SODIUM (mg/l)	25.70	42.16	86.32	23.49	41.10	66.23	28.43	50.09	73.10	25.98	42.92	68.79
POTASSIUM (mg/l)	6.25	7.99	11.49	4.55	7.14	15.73	7.20	13.57	34.50	5.91	13.70	32.05
CALCIUM (mg/l)	71.57	102.81	167.55	71.12	94.52	152.01	68.78	95.35	185.64	62.22	101.25	211.82
MAGNESIUM (mg/l)	24.20	45.08	72.93	25.63	38.65	60.55	25.75	37.84	49.50	25.65	42.43	92.82
AMMONIA-NITROGEN (mg/l)	1.20	2.78	9.52	0.37	2.14	9.32	0.00	1.38	4.57	0.11	1.63	7.23
NITRITE NITROGEN (mg/l)	0.06	0.17	0.34	0.06	0.17	0.54	0.05	0.13	0.44	0.07	0.13	0.78
NITRATE NITROGEN (mg/l)	4.25	8.21	9.84	1.78	6.38	10.21	0.92	3.74	7.62	0.41	5.23	9.62
TOTAL PHOSPHATE PHOSPHORUS (mg/l)	0.44	0.59	0.93	0.38	0.52	2.07	0.55	0.78	2.81	0.41	0.61	1.47
ORTHO PHOSPHATE PHOSPHORUS (mg/l)	0.25	0.59	0.89	0.15	0.48	0.78	0.41	0.64	2 15	0.25	0.57	1.19
ARSENIC (mg/l)	0 000	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.003
BERYLLIUM (mg/l)	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BORON (mg/l)	0.00	0.47	0.81	0.17	0.47	0.71	0.00	0.34	1.15	0.05	0.51	1.01
CADMIUM (mg/l)	0.000	0.000	0.041	0.000	0.000	0.007	0.000	0.000	0.014	0.000	0.000	0.024
CHROMIUM (mg/l)	0.007	0.017	0.054	0.003	0.014	0.048	0.000	0.010	0.054	0.003	0.010	0.034
COPPER (mg/l)	0.014	0.037	0.156	0.014	0.044	0.092	0.014	0.010	0.054	0.003	0.010	0.034
IRON (mg/l)	0.418	1.010	3.332	0.411	1.428	22.712	0.534	1.425	46.104	0.475	0.254	1.245
LEAD (mg/l)	0.000	0.007	0.024	0.000	0.010	0.092	0.000	0.010	0.377	0.000	0.003	0.041
MANGANESE (mg/l)	0.646	1.153	2.295	0.235	0.959	2.176	0.17009	0.262	1.686	0.51	0.388	1.561
NICKEL (mg/l)	0.00	0.00	0.20	0.00	0.00	0.06	0.00	0.00	0.30	0.00	0.00	0.10
SELENIUM (mg/l)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ZINC (mg/l)	0.000	0.129	0.544	0.024	0.146	0.496	0.014	0.065	0.275	0.000	0.061	0.214
MERCURY (µg/l)	0.000	0.000	1.360	0.000	0.000	1.360	0.000	0.000	0.856	0.000	0.000	1.516
COBALT (mg/l)	0.003	0.003	0.020	0.003	0.007	0.017	0.000	0.000	0.044	0.000	0.000	0.000

solubility changes, and chemical reaction due to cooling tower treatment with sulfuric acid. As a result of this concentration effect and the station chemical additions, the maximum predicted total dissolved solids concentration of the Limerick blowdown is estimated at 1136 mg/l. This is slightly above the maximum value given in the FES-CP of 1100 mg/l. This latter figure assumed all makeup water comes from the Schuylkill River. Using the more recent water quality data of the ER-OL and the above-mentioned Limerick operation and DRBC flow restriction simulation, the maximum predicted total dissolved solids concentration during the period January-May (when the Point Pleasant Diversion is not anticipated to be in use) is 1057 mg/l, or just below the value given in the FES-CP. Sulfuric acid treatment of Limerick cooling water for the control of scale and for the regeneration of demineralizers in the station water treatment plant is predicted to result in an increase in the median sulfate concentration in the blowdown over that of the intake water of between 25 mg/l and 54 mg/l, depending upon the makeup water source and composition. Median blowdown alkalinity concentrations would decrease by between 0 mg/l and 16 mg/l.

The applicant will control the discharge of total residual chlorine (TRC) in the Limerick discharge by the intermittent addition of biocide to the station condensers, treating one half of each condenser at a time, and mixing chlorinated and unchlorinated waters prior to the point where blowdown is withdrawn (ER-OL Section 3.6 and response to NRC staff question E291.11). Based on operating experience, field testing, and the expected intake water quality, the applicant estimates that the maximum two-unit TRC concentration in the Limerick blowdown would be 0.22 mg/l; this value would double if only one unit were operating during chlorination (response to NRC staff question E291.11). The estimated duration that TRC would be detectable (i.e., equal to or greater than 0.1 mg/l) in the Limerick blowdown is about 50 minutes for two-unit operation and about 77 minutes for one-unit operation for each chlorination cycle. The applicant has indicated that residual chlorine concentration will be monitored in the station blowdown line. During the infrequent chlorination of the cooling towers for control of excess biological growths, blowdown will be suspended until the free available chlorine (FAC) concentration in the tower basin falls below 0.5 mg/l.

The applicant has not decided on a final plan for the cleaning of cooling water systems outside the condenser cooling water system (response to IE Bulletin 81-03). The service water system shares the station cooling towers with the circulating water system and, therefore, receives biofouling treatment via the condenser/cooling tower treatment scheme. The heat exchangers of the service water systems and the closed water systems may be isolated so that cleaning waste solutions may be controlled and treated before disposal.

The amount of dissolved solids expected to escape from the station's cooling towers in the drift during operation has changed since the FES-CP was issued. As indicated in Section 4.2.3.2, the average concentration factor has decreased to about 3.4, and the projected drift loss rate for the cooling towers is now 0.03% of the circulating water flow rate. Based on these values, up to about 590 kg/day/unit (1300 lb/day/unit) and 886 kg/day/unit (1950 lb/day/unit) could be dispersed in the Limerick drift, based on the projected maximum median total dissolved solids concentration and on the projected overall maximum total dissolved solids concentration in the circulating water, respectively.

4.2.6.3 Chemical Waste Systems

The station chemical waste treatment facility treats all nonradioactive wastewaters except the cooling tower blowdown, spray pond overflow, and sanitary wastes. These wastewater types are similar to those indicated in the FES-CP and consist primarily of demineralizer regenerants, filter flush wastes, clarifier sludges, oily waste, and floor drainage. All of these wastes are discharged, after appropriate treatment, to the cooling tower blowdown.

The changes in the chemical waste treatment system design since the FES-CP was issued consist of the addition of a final 1.5×10^6-l (400,000-gal) holding pond where liquid wastes from the settling basins can be sampled and proportionately released into the station cooling tower blowdown line to the Schuylkill River and a change to the settling basin from a single 1.5×10^5-l (40,000-gal) capacity tank to two tanks of 1.14×10^5-l (30,000-gal) capacity each. Wastewater flows to the settling basins are shown on Figure 4.2 for average conditions. The maximum wastewater flow rate to the basins is projected to be about 3.4×10^5 l/day (90,000 gpd). Settling basin effluent is expected to contain 30 mg/l suspended solids and about 1300 mg/l total dissolved solids, consisting largely of sodium sulfate from the regeneration of the water demineralizers. The settling basin effluent is routed to the holding pond. Average and maximum inflows to the holding pond are expected to be 2.65×10^5 l/day (70,000 gpd) and 1.14×10^6 l/day (300,000 gpd), respectively. Wastes in the pond are continuously monitored for pH (between 6.0 and 9.0 standard units) and turbidity during the average 24-hour retention period before release.

Other inflows to this system include

(1) The circulating water pump structure sump pump effluent, amounting to 3785 l/day (1000 gpd) average flow and 37850 l/day (10,000 gpd) maximum flow draining through oil separators to the holding ponds.

(2) Auxiliary boiler blowdown, amounting to about 3785 l/day (1000 gpd) draining through oil separators and filters to remove iron and copper to the holding pond. This waste will also contain less than 0.45 kg/day of sodium sulfite and trisodium phosphate from the scale and corrosion control program of the boilers. These wastes will comply with EPA point source limitations for boiler blowdown (40 CFR 423) before release to the holding pond.

(3) Storm water drainage from station surfaces, amounting to about 18,925 l/day (5000 gpd) draining through oil separators to the holding pond.

(4) Powerblock subdrainage sump pump flow, amounting to an average of 3725 l/day (10,000 gpd).

(5) Nonradioactive floor and equipment drains from the station amounting to about 1.06×10^5 l/day (28,000 gpd).

The wastes from the holding pond are shown on Tables 4.2 and 4.3 for amounts and discharge concentrations, respectively. These wastes are mixed fully with the station discharge before discharge and are not expected to cause the station discharge composition to be significantly different from the cooling tower blowdown alone.

4.2.6.4 Spray Pond Overflow

Effluent from the spray pond will consist of (1) excess volume that results from precipitation and (2) blowdown to maintain chemical water quality. The effluent from the spray pond is routed directly to the cooling tower blowdown line and will consist of Schuylkill River water concentrated about 1.4 times because of surface evaporation. The pond will be treated periodically with sodium hypochlorite to control algae. The maximum free available chlorine (FAC) of the pond blowdown that will be permitted is 0.5 mg/l (response to NRC staff question E291.9). Based on average meteorological conditions, blowdown is projected to take place daily, for one-half hour each day. The amount of blowdown during each one-half hour episode is expected to average 45,400 l (12,000 gal) with a maximum of 68.1 x 10^4 l (180,000 gal) for a 6-hour-a-day episode, based on a worst case evaporative water loss with no precipitation (response to NRC staff question E291.8).

4.2.6.5 Sanitary Waste Treatment System

The sanitary waste treatment system presently proposed for use during Limerick operation is of the same type discussed in the FES-CP. The estimated sewage volume during operation is now given as 37,850 l/day (10,000 gpd) for a workforce of about 350 persons. The estimated sewage volume given in the FES-CP was 20,439 l/day (5400 gpd).

The sanitary waste treatment facility was constructed under Pennsylvania DER Sewage Permit No. 4672437 and is operated under NPDES Permit No. PA 0024414.

4.2.7 Power Transmission System

Descriptions of the transmission line system are in Section 3.2 of the ER-CP and Section 3.7 of the FES-CP. A map of the transmission network for the Limerick Station is shown in Figure 4.4. Two new lines have been added to the transmission system since the construction permit was issued (ER-OL Section 3.9): a new 230-kV line from the Cromby generating station to North Wales will be constructed on existing transmission line right of way, and another 230-kV line will be constructed along existing transmission line and railroad ROW between the Cromby and Plymouth Meeting substations.

The 230-kV line from Cromby to the North Wales substation will be approximately 25.5 km (16 miles) long, with the right of way varying from 46 to 91 m (150 to 300 feet) in width. Over the first 24 km (15 miles), the conductors will be supported by tubular single-circuit towers, with tower placement varying from 91 to 182 m (600 to 1200 feet), depending on the terrain. For the final mile of line, conductors will have to be strung on double-circuit vertical tubular towers because of the narrowness of the right of way.

The 230-kV line from the Cromby substation to the Plymouth Meeting substation will be approximately 22 km (13.5 miles) long, constructed on existing Conrail and Philadelphia Electric Company rights of way. The 13.5-km (8.5-mile) line segment from Cromby to Haws Avenue, in Norristown, will be constructed with tubular steel towers spaced at 91- to 244-m (300- to 800-foot) intervals. Tower intervals of 300 m (1000 feet) or more will be needed at Schuylkill River crossings. The conductor stringing configuration will vary with location, and the right-of-way width will vary from 19 m (60 ft) to more than 30 m (100 feet).

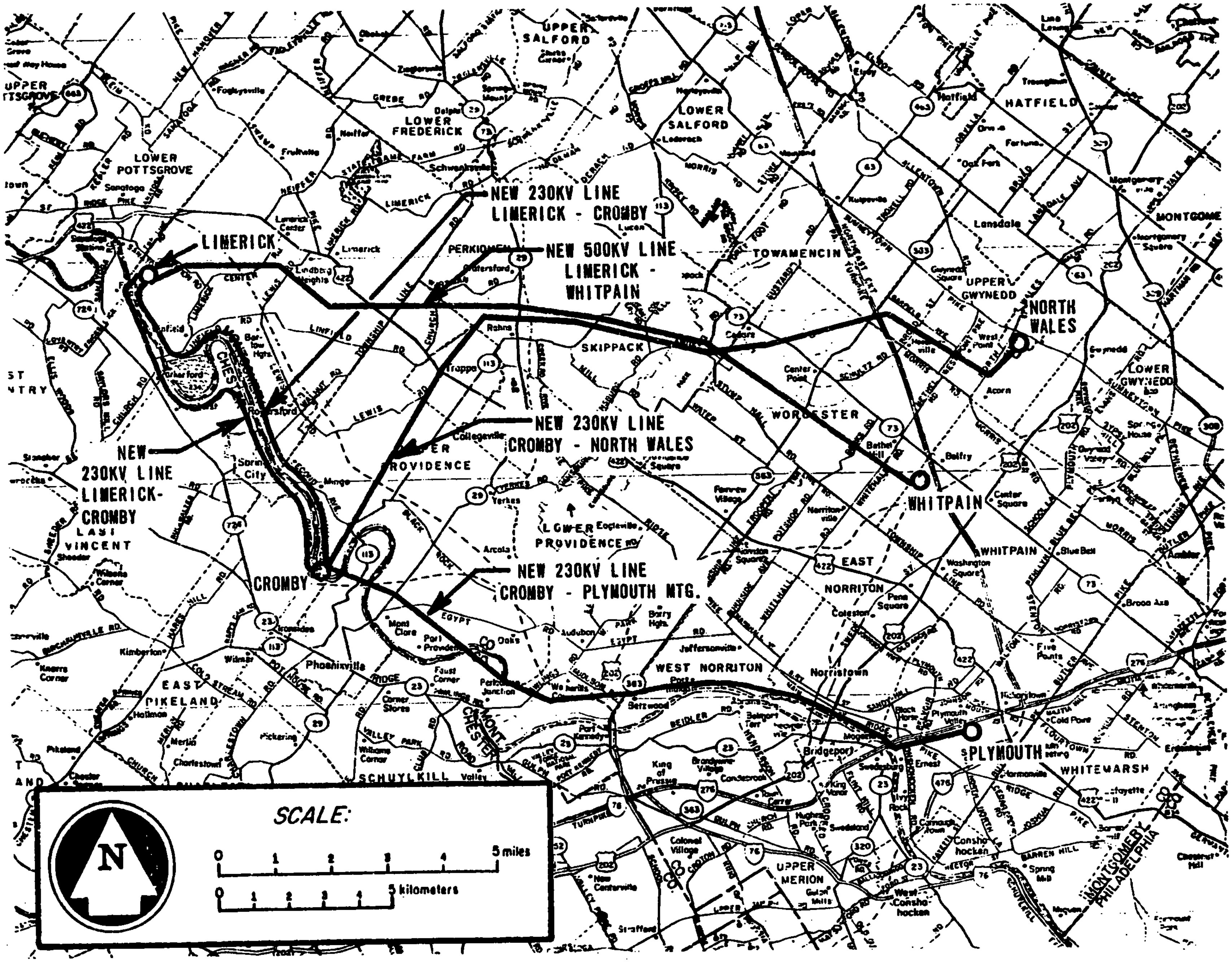

Figure 4.4 Transmission network for Limerick station

From Cromby to Oaks, Pennsylvania, the line will follow the existing Cromby-to-Barbadoes 69-kV line right of way. From Oaks to the Plymouth Meeting substation, the line will follow the Conrail right of way. Wide flange steel towers and tubular steel poles (ER-OL Figures 3.9-6 and 3.9-7) will be used to support the conductors between Haws Avenue and the Plymouth Meeting substation. A more detailed description of the new transmission lines is in Section 3.9 of the ER-OL.

4.3 Project Related Environmental Descriptions

4.3.1 Hydrology

4.3.1.1 Surface Water

The surface water descriptions in Section 2.5 of the FES-CP are still valid, with the additions and discussions below. In addition, Section 5.3.3 of this report contains a discussion of the hydrologic effects of alterations in the floodplain, as required by Executive Order 11988 - Floodplain Management.

A description of the supplemental cooling water system (SCWS) and a map relating the site to the various streams that are part of the SCWS are in Section 4.3.1.2. The impacts of the SCWS are discussed in Section 5.3.3.

4.3.1.1.1 Schuylkill River

The drainage area of the Schuylkill River at the plant site is 3025 km^2 (1168 mi^2). Near the site, the Schuylkill River is a meandering stream, with a bed slope of 0.04 to 0.05%. It is flanked by floodplains comprised of about 10% builtup areas, 30% forest growth, and 60% cultivated or fallow fields.

Three major dams--Blue Marsh, Ontelaunee, and Maiden Creek--exist or are planned in the Schuylkill River Basin upstream of the Limerick station. Blue Marsh is a newly constructed (1979) U.S. Army Corps of Engineers dam, about 56 km (35 miles) upstream of Limerick on the Tulpehockan Creek. It has a total storage capacity of 61.7×10^6 m^3 (50,000 acre-feet), of which 28.2×10^6 m^3 (32,390 acre-feet) are reserved for flood control. The maximum height of this dam is 29.3 m (96 feet). Ontelaunee dam is owned by the City of Reading. It is located on Maiden Creek, about 59.2 km (37 miles) upstream of the Limerick plant. This dam is 15.8 m (52 feet) high, with a storage capacity of 14.7×10^6 m^3 (11,900 acre-feet). The Maiden Creek Dam, authorized for future construction by the U.S. Army Corps of Engineers, will be located on Maiden Creek, about 8 km (5 miles) upstream of Ontelaunee dam. The planned height of the dam is 33.5 m (110 feet), with a storage capacity of 141×10^6 m^3 (114,000 acre-feet).

The applicant has reviewed historical data from 54 years (1927 to 1980) to determine statistical flow parameters of the Schuylkill River. The average flow over this period was 54 m^3/s (1910 ft^3/s). The instantaneous minimum flow was 2.5 m^3/s (87 ft^3/s), which occurred on August 13, 1930. Low flow frequency curves for 1, 3, 7, 14, 30, 60, and 120 consecutive-day flows for the Schuylkill River at Pottstown (U.S. Gauge 01472000 approximately 9.6 km upstream of the site), as well as a flow duration curve, are in the ER-OL. The 7-consecutive-day, 10-year low flow determined by the applicant for the Schuylkill River at Pottstown is 7.37 m^3/s (260 ft^3/s).

The 100-year flood peak discharge on the Schuylkill River at the plant site was determined to be 2238 m^3/s (79,000 ft^3/s). Downstream domestic and industrial users of surface water on the Schuylkill River are listed in the ER-OL. The total entitlement for domestic use is 13.3 m^3/s (470 ft^3/s), of which 0.8 m^3/s (28 ft^3/s) is for consumptive use. The total entitlement for industrial use is 28.9 m^3/s (1020 ft^3/s), of which 0.6 m^3/s (20 ft^3/s) is for consumption. The listed entitlements are current as of August 1980.

4.3.1.1.2 Perkiomen Creek

Perkiomen Creek, which lies to the east of the Limerick site, is a major natural component of the supplemental makeup water system. Perkiomen Creek and the East Branch of Perkiomen Creek will act as an open conveyance for water being pumped from the Delaware River to the Limerick station. When Delaware River water is withdrawn for use by the Limerick station, it will first be pumped to the Bradshaw Reservoir (which divides flow between the Philadelphia Electric Company and the Neshaminy Water Resources Authority) and then from the reservoir to the East Branch of Perkiomen Creek. The water would then flow about 35.5 km (22.2 miles) to an intake on the Main Stem of Perkiomen Creek about 1 km (0.6 mile) south of Graterford, Pennsylvania.

The drainage area of Perkiomen Creek at Graterford is 723 km^2 (279 mi^2) and has an average discharge of 11 m^3/s (389 ft^3/s). The average monthly flows, as determined from the period of record (1914 to 1980), are listed in the ER-OL. Also in the ER-OL are low flow frequency curves for 1, 3, 7, 14, 30, 60, and 120 consecutive days.

The 100-year flood peak discharge in the vicinity of the intake pump structure was determined to be 1199 m^3/s (42,300 ft^3/s), and the corresponding water level 125.7 feet msl. The 100-year flood discharge on the East Branch of Perkiomen Creek in the vicinity of the pipeline discharge is 74 m^3/s (2,600 ft^3/s). The corresponding water level is 361 feet msl.

4.3.1.1.3 Delaware River

When DRBC restrictions preclude use of Schuylkill River water and when flow conditions on the Delaware permit, water for Limerick will be withdrawn from the Delaware River near Point Pleasant, Pennsylvania, and pumped to the Bradshaw Reservoir. The drainage area of the Delaware River at Point Pleasant is approximately 17,100 km^2 (6600 mi^2). The average annual flow of the Delaware River at Trenton, New Jersey (drainage area = 17,560 km^2 (6780 mi^2)) for the period of record (1912 to 1980) is 333 m^3/s (11,748 ft^3/s). Average monthly flows for this period for the Delaware River at Trenton are listed in the ER-OL.

Flows in the Delaware River at Point Pleasant are presently regulated by Lakes Wallenpaupack, Hopatcong, Pepacton, Cannonsville, Swinging Bridge, Toronto, Cliff, Neversink, and Wild Creek, and several other smaller reservoirs. Releases from the upstream reservoirs are capable of maintaining a flow of 85 m^3/s (3000 ft^3/s) at Trenton during a moderate drought. Sufficient capacity and operational procedures are planned to maintain a flow of 70.8 m^3/s (2500 ft^3/s) to 82.2 m^3/s (2900 ft^3/s) at Trenton should a drought of the severity of the 1960s drought occur. The estimated recurrence interval of that drought is 100 to 300 years. The water level for a Delaware River flow of 85 m^3/s (3000 ft^3/s)

at Point Pleasant is about 71 feet msl and is controlled by the Lumberville Wing Dam about 1.6 km (1 mile) downstream.

The 100-year flood peak discharge for the Delaware River at Point Pleasant is 8048 m^3/s (284,000 ft^3/s). The corresponding water level for the 100-year flood at Point Pleasant is 103 feet.

4.3.1.2 Groundwater

The plant region is underlain by the Newark group of Triassic age, which includes the Stockton Formation and the overlying Lockatong, Hammer Creek, and Brunswick lithofacies. These strata are intruded by diabase dikes and sills. Although the other units provide some groundwater in the region, the Brunswick lithofacies is the only aquifer of significance at the plant site and yields small to moderate quantities of water to wells. Water for plant operation is obtained from surface water, and no groundwater use is planned.

The Brunswick stratum is composed of red shale, sandstone, and siltstone. Most of the groundwater movement follows secondary openings that developed after the deposition of the beds. The most important openings are nearly vertical joint planes that cross each other at various angles throughout the beds. These joints provide an interconnected series of channels through which groundwater can flow, giving the material a low to moderate permeability.

Recharge to the Brunswick aquifer occurs through the soil cover as precipitation percolates down to the water table. The water table generally follows the surface of the land, and groundwater flows from high to low topographic areas. Most groundwater movement is in the upper portion of the aquifer where the fracture density is greatest.

Groundwater is used for several domestic and commercial supplies in the vicinity of the site. Most of the wells are less than 61 m (200 feet) deep and yield less than 380 l/m (100 gpm). Publicker Industries, located 2.4 km (1.5 miles) south of the site, is the largest groundwater user in the vicinity of the site. It uses 568 m^3/day (150,000 gpd) from three wells in the Brunswick aquifer. Water wells in the site vicinity are either not in the same groundwater basin as the plant or are hydraulically upgradient of the plant.

4.3.1.3 Water Use

The average annual water use for the Limerick generating station will be 47.1 mgd for two-unit full power operation. Of this amount (which, in addition to evaporative losses, also includes drift and miscellaneous losses), 14.1 mgd is returned to the Schuylkill River as blowdown. The average water use by month is tabulated in the ER-OL.

Water to replace evaporative, drift, and miscellaneous losses may be drawn from the Schuylkill River, Perkiomen Creek, or the Delaware River, depending on flow and temperature. Figure 4.5 is a map showing the major hydrologic components of the SCWS. Cooling tower blowdown will be made up from and discharged to the Schuylkill River only. While the plant is operating, there will always be a withdrawal from the Schuylkill River to replace the blowdown. Water for consumptive use can be drawn from the following three alternate sources under the restrictions imposed by the Delaware River Basin Commission (DRBC, 1975; DRBC, 1981):

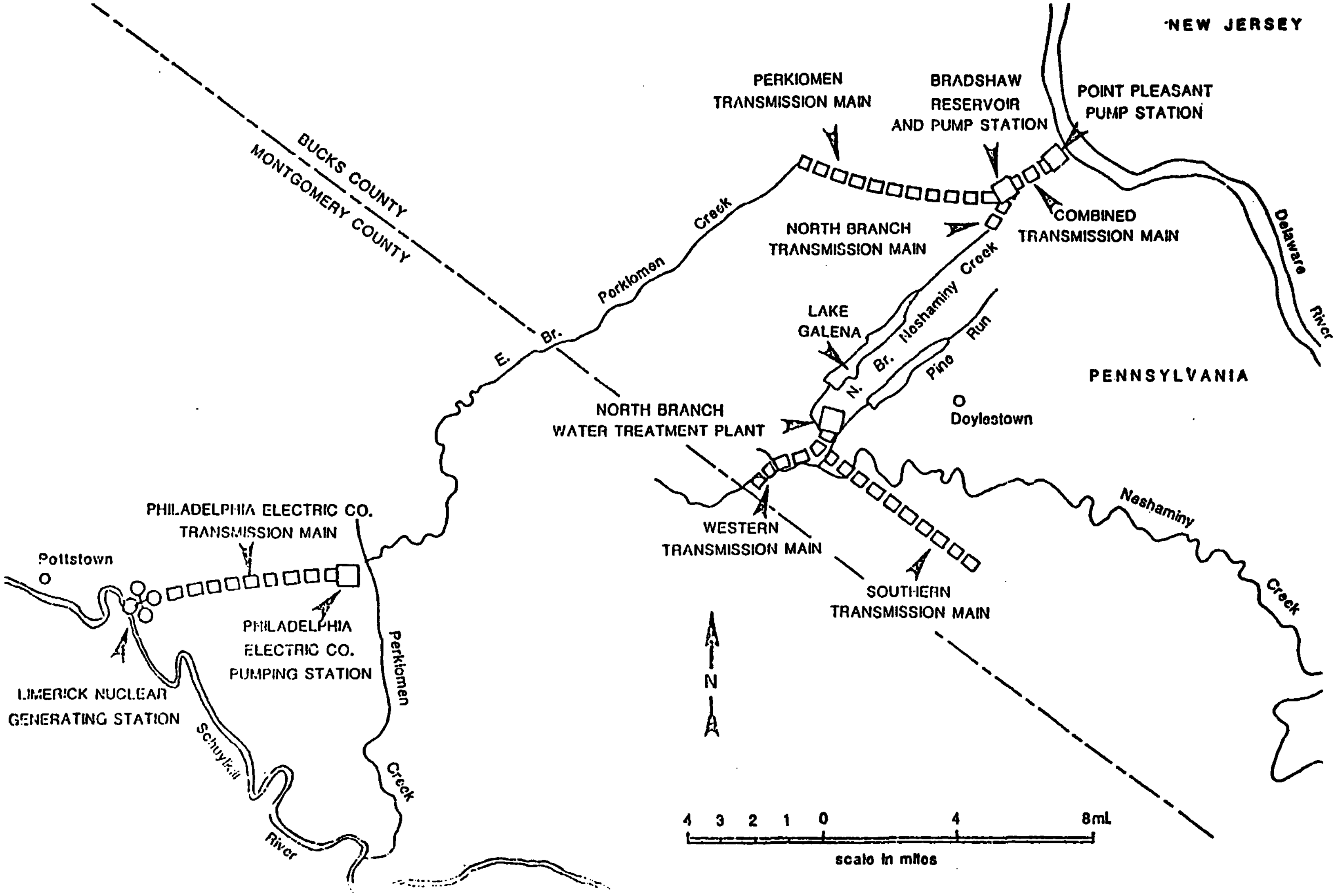

Figure 4.5 Neshaminy water supply system

Source: Delaware River Basin Commission
Docket No. D-79-52CP

(1) Schuylkill River

Schuylkill River water at the plant may be used for consumptive use when flow (not including future augmentations of flow from DRBC-sponsored projects) as measured at the Pottstown gage is in excess of 15 m^3/s (530 ft^3/s) with one unit in operation and 15.9 m^3/s (560 ft^3/s) with two units in operation with the following exceptions:

(a) There shall be no withdrawals when river water temperatures downstream of the Limerick station are above 15°C except during April, May, and June and then only if the flow as measured at the Pottstown gage is in excess of 50.8 m^3/s (1791 ft^3/s).

(b) Use of the Schuylkill River will be limited to a withdrawal that will result in an effluent that meets all applicable water quality standards.

Both sets of constraints would be suspended in the event of any operational emergency requiring a shutdown of the plant.

(2) Perkiomen Creek

Perkiomen Creek water may be used when flows as measured at the Graterford gage are in excess of 5.1 m^3/s (180 ft^3/s) with one unit in operation and 6.0 m^3/s (210 ft^3/s) with two units in operation, exclusive of any water pumped from the Delaware River.

(3) Delaware River

The Delaware River water, as augmented for the purpose of water supply by upstream reservoirs, may be used via the Point Pleasant pumping facilities, Bradshaw Reservoir, a pipeline, the East Branch of Perkiomen Creek, and Perkiomen Creek, with the limitations that such use will not reduce the flow as measured at the Trenton gage to below 85 m^3/s (3000 ft^3/s), and that such use will not be permitted when the flow as measured at the Trenton gage is less than 85 m^3/s (3000 ft^3/s). Also, each year, after pumping from the Delaware River has begun, pumping is maintained in the East Branch as measured at Bucks Road at not less than 0.76 m^3/s (27 ft^3/s) throughout the normal low flow season until pumping from the Delaware River is no longer required for the operation of Limerick station. The rest of the year, the Philadelphia Electric Company will maintain a flow of 0.28 m^3/s (10 ft^3/s) in the East Branch of Perkiomen Creek.

If the Merrill Creek Reservoir on the Delaware above Point Pleasant in New Jersey is built and becomes operative, pumping for Limerick will be allowed when the flow at Trenton is below 85 m^3/s (3000 ft^3/s), provided that compensating flows are released from Merrill Creek Reservoir. Merrill Creek Reservoir will contain 56.76 x 10^6 cm (46,000 acre-feet) of usable water supply and would yield approximately 5.7 m^3/s (200 ft^3/s) of compensatory release for 115 days during a recurrence of the drought of the 1960s. Merrill Creek Reservoir will be owned by a group of seven utilities, including the Philadelphia Electric Company.

The supplemental cooling water system is designed to withdraw water at a maximum flow of 1.84 m^3/s (42 mgd) from the intake in Perkiomen Creek. The Point Pleasant pumping station will be sized to provide 2.03 m^3/s (46.2 mgd) to the Limerick supplemental cooling water system, including a 10% allowance for losses in transit. The maximum average monthly amount of consumptive water to be drawn from the supplemental cooling water system is 37.1 mgd, which will occur in July under two-unit full-power operation and average meteorological conditions. The maximum demand (42 mgd) was determined by combining the maximum evaporative loss with the maximum miscellaneous and drift losses, even though these losses are not expected to occur concurrently.

4.3.2 Water Quality

4.3.2.1 General

The mean and range of values of measured physical and chemical constituents of the Delaware River, Perkiomen Creek, and the Schuylkill River were presented in FES-CP Table 3.6. These data were updated during the applicant's aquatic chemistry program that was initiated in May 1974. This program included sampling every 2 weeks at stations on the Delaware River, the East Branch of Perkiomen Creek, Perkiomen Creek, and the Schuylkill River. Detailed information on the constituents sampled, citation of analytical techniques used, and results of analyses are presented in ER-OL Sections 2.4 and 6.1.1 and in answers to NRC staff questions E291.2, E291.3, and E291.23. The following subsections address the quality of the waters to be used by Limerick operation, as assessed by the NRC staff and by the Commonwealth of Pennsylvania and the DRBC.

4.3.2.2 Delaware River

Water quality standards and usage criteria applicable to the Delaware River in the vicinity of Point Pleasant have been set by both the DRBC and the Commonwealth of Pennsylvania.

The Commonwealth of Pennsylvania, under Chapter 93 of the Rules and Regulations of the Department of Environmental Resources, has designated the maintenance and propagation of warm water fishes and the passage, maintenance, and propagation of migratory fishes as protected uses of the Delaware River at this location. Both general and specific water quality criteria necessary to protect these uses have been established by the Commonwealth for these waters. The DRBC, under Article 3 of the DRBC Basin Regulations (Water Quality), has designated the following water uses to be protected: public water supply after reasonable treatment, industrial water supply after reasonable treatment, agricultural water supply, maintenance of resident game fish and other aquatic life, spawning and nursery habitat for anadromous fish, passage for anadromous fish, wildlife, and recreation. Stream quality objectives have been assigned for this reach of the river to protect these uses.

The water quality of the stretch of the Delaware River that includes Point Pleasant has been examined by the DRBC, the U.S. Army Corps of Engineers (in connection with its review of the application for a dredging permit under Section 404 of the Clean Water Act), and the Commonwealth of Pennsylvania, in addition to the applicant. In the Delaware River Basin Comprehensive (Level B) Study (DRBC, 1981), DRBC indicated that water quality is improving in the Delaware River and most basin streams. General water quality problems and issues were identified for the river above Trenton, New Jersey as follows: (1) occasionally high fecal coliform levels, (2) occasionally low localized dissolved oxygen levels, and (3) high turbidity during storms. This report also mentions that some of the pollutants on the U.S. Environmental Protection Agency List of Priority Pollutants are present in the surface water and groundwater of the basin. However, the quantities detected were characterized as "minute" in almost all cases.

In a more recent report, the DRBC characterized the water quality in the Delaware River between Easton, Pennsylvania, and Trenton as "good," meaning "minor or localized pollution problems. Water quality standards are not violated in most samples or in major sections of the river reach....Wastewater discharges to the River reach generally meet applicable effluent requirements" (DRBC, 1982). In addition, the DRBC stated in this report that this reach of the river meets the 1981 "swimmable" and "fishable" goals, as established under the Clean Water Act of 1977, and was expected to meet these goals in 1983. The DRBC used its standards for fecal coliform bacteria levels, along with subjective considerations concerning the potential for the presence of toxic pollutants, to assess the attainment of the "swimmable" goal for this river reach. The concerns about this reach specifically identified in this study are: (1) occasionally high fecal coliform levels are a seasonal local problem; (2) phytoplankton has been found to be seasonally high in lower part of the river reach; and (3) dissolved oxygen concentration in the summer has been occasionally low at some locations.

In a report prepared for the U.S. Army Corps of Engineers (BCM, 1981), the quality of the Delaware River in the vicinity of Point Pleasant is described as being similar to that described above. The report also notes that there have been improvements in water quality over the period of 1971 to 1975, notably in levels of coliform bacteria counts and phenols.

The water quality of the Delaware River in the Lumberville area is assessed by the Commonwealth of Pennsylvania (Penna, 1980) as "presently very good." The report cites normal variability of temperature, pH, and alkalinity for a river such as the Delaware, although the maximum pH and minimum alkalinity values set by the DRBC have been exceeded at times. Nutrient and other oxygen-demanding substance loadings are not significant, in terms of reductions of dissolved oxygen concentrations and increases in phytoplankton densities and rooted aquatic vegetation. Dissolved oxygen concentrations are normally above the minimum value, as set by DRBC standards, although periodic summer morning depressions below 5 mg/l have been found to occur at two locations. These occurrences have been attributed to algal blooms in the river.

The Commonwealth's analysis of the water quality monitoring data indicates that the river quality in the Point Pleasant vicinity is within acceptable limits for all parameters (ibid.). Toxic and priority pollutants were at or below detectable limits. The Commonwealth concludes that there presently is "...no substantial evidence that the Delaware River water in the vicinity of Point Pleasant contains significant levels of toxics or priority pollutants" (ibid.).

Based on studies conducted from 1974 through 1978, the applicant, in the ER-OL, characterized the water quality of the Delaware River as "relatively good in that it is well buffered and does not contain excessively high concentrations of major cations and anions or ions considered essential plant nutrients"

(ER-OL page 2.4-7). The results of the applicant's sampling of the river at the proposed Point Pleasant intake location and at an upstream control location are summarized in the ER-OL, on a seasonal basis, for the period 1975-1978. Additional data from these sampling locations through the beginning of June 1982 have been made available to the staff. The data for the entire record are summarized in Tables 4.4 and 4.5. The applicant's analysis of the newer data resulted in no noted significant differences from the data reported in the ER-OL, and no changes to the conclusions reached in the ER-OL as to the water quality relative to applicable standards (response to NRC staff question E291.3).

A review of the data with respect to the DRBC and Pennsylvania water quality standards indicates that, for those constitutents with numerical criteria limitations, the mean and median constituent values found do not violate the criteria, except for phosphorus and fecal coliform bacteria counts. The water quality of the river with respect to bacteria counts appears to be improving, as the bacteria counts appear to be decreasing over the recent period of record, 1978 to 1982. Infrequent violations of the numerical criteria of the DRBC and Pennsylvania DER are noted in the sampling data over the period of record when the maximum values of the constituents are considered. This finding applies to limitations on pH (upper limit exceeded), total dissolved solids, ammonia, phosphates, cadmium, chromium, iron, cyanide, and phenols.

In addition to cadmium, chromium, cyanide, and phenols, as mentioned above, eight additional metals that appear on the EPA List of Priority Pollutants (as defined under Section 304(a)(1) of the Clean Water Act, and as listed in the Federal Register (45 FR 79318, November 28, 1980)) were analyzed from samples taken from the Delaware River. The results of these analyses are given in Table 4.5. The average concentration values for these metals are below those indicated in the EPA water quality criteria documents as being harmful to aquatic life.

Sample data on the occurrence of other substances appearing on the EPA List of Priority Pollutants for the Delaware River in the vicinity of Point Pleasant are too limited to be considered reliable. Sampling and measurement of pesticides were performed by EHBA, Inc. for the Neshaminy Water Resources Authority (NWRA) on July 15, 1980 (for 2, 4, -D, and Silvex) and on July 23, 1980 (for lindane, chlordane, endrin, heptachlor, hepta-epoxide, methoxychlor, and toxaphene) (Roeder, 1982). The results of these measurements from samples taken from the Delaware River at Point Pleasant indicate that, for all of these pesticides and herbicides, concentrations were below the limit of detection used by EHBA, Inc., 0.001 mg/l. Samples collected on August 20, 1978, for these same pesticides and herbicides were also reported by NWRA to be below the detection limits.

Measurements on Delaware River water from the vicinity of Point Pleasant have been made by the applicant since March 1980 for trichloroethylene (TCE). Before March 1982, sampling was expanded to several stations in the proposed Point Pleasant Diversion vicinity. TCE was detected sporadically at these locations only during the period of March to June 1982 (in 6 of 32 samples from the river). The range of concentrations found was 0 to 4.0 μg/l.

The data records available for all of the water quality constituents measured in the Delaware River in the vicinity of Point Pleasant are not consistently complete to the last sampling year (1982; not all constituents have been sampled

Table 4.4 Limerick makeup water source quality

	Water Body Ambient Concentrations[1]							
	Delaware River[2]		East Branch[3]		Perkiomen Creek[4]		Schuylkill River[5]	
Parameter	Avg	Range	Avg	Range	Avg	Range	Avg	Range
Temperature, °C	13.1	0.0-29.0	11.9	0.0-27.5	12.9	-0.5-29.0	13.8	-1.0-30.0
pH	7.81	6.55-9.22	7.52	6.94-8.26	8.05	7.01-9.95	7.67	7.00-8.47
Dissolved oxygen	10.3	5.0-17.2	9.7	4.9-14.2	10.9	5.0-17.0	8.9	3.4-15.0
Biochemical oxygen demand	1.9	0.0-6.8	1.5	0.0-6.3	1.9	0.0-7.0	2.5	0.0-8.4
Total hardness	66.0	35.0-134.7	86.3	36.5-142.0	90.8	48.8-507.7	139.9	51.9-724.9
Alkalinity	42.6	8.7-82.7	50.4	13.0-95.7	55.0	6.6-104.2	67.4	4.3-172.1
Total dissolved solids	121	37-260	162	0-294	174	0-466	248	12-546
Chloride	13.0	3.3-49.4	24.3	7.8-109.4	24.4	8.9-102.4	24.8	8.1-62.4
Sulfate	28.0	2.7-87.8	34.6	20.3-82.1	34.8	7.4-101.0	82.0	24.6-211.9
Ammonia nitrogen	0.084	0.000-0.700	0.022	0.000-0.150	0.088	0.000-0.890	0.277	0.000-2.292
Nitrite nitrogen	0.028	0.000-0.220	0.018	0.000-0.400	0.028	0.000-0.220	0.076	0.000-0.900
Nitrate nitrogen	1.09	0.00-5.90	1.10	0.00-4.08	1.46	0.00-4.01	2.47	0.00-5.60
Total phosphate phosphorus	0.12	0.00-1.09	0.05	0.00-0.46	0.15	0.00-2.98	0.27	0.00-3.48
Ortho phosphate phosphorus	0.06	0.00-0.23	0.02	0.00-0.18	0.09	0.00-0.42	0.16	0.00-0.85
Total iron	0.41	0.00-3.64	0.41	0.05-8.38	0.51	0.000-8.99	0.58	0.009.31
Manganese	0.06	0.00-0.48	0.06	0.00-0.44	0.05	0.00-0.67	0.26	0.00-1.26
Magnesium	6.50	0.00-14.10	10.42	4.57-16.14	8.87	2.90-15.00	15.38	3.60-35.80
Sodium	8.73	3.05-36.10	12.26	4.27-57.21	13.41	3.20-41.00	17.19	3.46-62.00
Calcium	15.1	4.2-31.9	18.7	8.0-35.5	21.2	8.8-41.6	33.6	5.9-83.5

Source: PECo Water Quality Data, September 1982.

[1]All concentrations in mg/l unless otherwise noted. [2]Data from Point Pleasant, Pa. [3]Data from sampling location #32300-headwaters. [4]Data from sampling location #14390-Graterford intake. [5]Data from sampling location #77140-Schuylkill Limerick discharge.

Table 4.5 Limerick makeup water source quality, U.S. EPA priority pollutants

Parameter	Water Body Ambient Concentrations[1]							
	Delaware River[2]		East Branch[3]		Perkiomen Creek[4]		Schuylkill River[5]	
	Avg	Range	Avg	Range	Avg	Range	Avg	Range
Arsenic	n.d	n.d	n.d	n.d	0.000	0.000-0.004	0.000	0.000-0.012
Beryllium	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.000	0.000-0.001
Cadmium	0.001	0.000-0.011	0.001	0.000-0.005	0.013	0.000-1.4	0.001	0.000-0.013
Chromium	0.007	0.000-0.076	0.001	0.000-0.008	0.003	0.000-0.048	0.008	0.000-0.194
Copper	0.023	0.000-2.001	0.008	0.000-0.080	0.008	0.000-0.122	0.016	0.000-0.840
Cyanide	0.002	0.000-0.013	n.s	n.s	0.000	0.000-0.005	0.001	0.000-0.008
Lead	0.003	0.000-0.031	0.004	0.000-0.134	0.030	0.000-5.368	0.006	0.000-0.348
Mercury (μg/l)	0.1	0.1-0.4	0.3	0.0-20.0	0.0	0.0-0.9	0.1	0.0-7.1
Nickel	0.00	0.00-0.06	0.00	0.00-0.04	0.00	0.00-0.05	0.00	0.00-0.57
Phenols	0.003	0.00-0.033*	n.s	n.s.	0.002	0.000-0.027	0.003	0.000-0.050
Selenium	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Trichloroethylene (μg/l)	0.1	0.0-0.4	n.s	n.s.	n.d.	n.d.	0.3	0.0-6.2
Zinc	0.06	0.00-0.48	0.01	0.00-0.41	0.02	0.00-0.53	0.06	0.00-8.34

Source: Response to question E291.23; PECo Schuylkill River Water Quality Data, September 1982

Notes:

n.d. - not detected; n.s. - not sampled for

[1]All concentrations in mg/l unless otherwise noted.
[2]Data from Point Pleasant, Pa.
[3]Data from sampling location #32300-headwaters.
[4]Data from sampling location #14390-Graterford intake.
[5]Data from sampling location #77660-Schuylkill intake.

for all years). However, because the applicable criteria have been exceeded only infrequently, the staff believes that the data available support the conclusions of the DRBC and the Commonwealth of Pennsylvania given above regarding the condition of the river in this reach.

4.3.2.3 East Branch of Perkiomen Creek

The water quality of the East Branch of Perkiomen Creek has been reviewed and compared with that of the Delaware River (as characterized for the Point Pleasant area) by the Commonwealth of Pennsylvania (Penna, 1980). For the period 1975-1979, the East Branch of Perkiomen Creek is cited as showing some minor localized improvement in water quality as a result of the installation and operation of industrial waste treatment systems. However, the same report indicated that at least portions of the East Branch and the Main Stem of Perkiomen Creek were not expected to meet water quality standards by the end of 1983. The report cites the presence of oxygen-consuming materials and nutrient problems "due to inadequately treated industrial and municipal waste discharges and non-point source problems" as the reasons the standards would not be met. The assessment of the Point Pleasant Diversion by the commonwealth concludes that the water quality of the East Branch of Perkiomen Creek is at best equivalent to that of the Delaware River in the vicinity of Point Pleasant and is degraded in the lower reaches (Penna, 1982).

The DRBC notes (DRBC, 1980) that the water quality of the East Branch of Perkiomen Creek is generally compatible with that of the Delaware River in the vicinity of Point Pleasant, but that the stream ammonia values tend to be lower than the river concentrations and that stream nitrate concentrations appear higher than the river concentrations. The DRBC also notes the above-cited degraded water quality in the lower reaches as reported by the applicant and the COWAMP/208 Plan for 1978.

The Commonwealth of Pennsylvania has established that the following water uses be protected in the East Branch of Perkiomen Creek: "Maintenance of stocked trout from February 15 to July 31 and maintenance and propagation of fish species and additional flora and fauna which are indigenious to a warm water habitat" (Penna, 1982, Chapter 93, Rules and Regulations).

Water quality data for the East Branch of Perkiomen Creek were collected by the applicant at several stations along the 36 km (22.4 miles) between the Delaware outfall and the confluence with the Main Stem of the Perkiomen Creek. These data were collected during the period of May 1974 through December 1978 and are summarized in ER-OL Tables 2.4-14 and 2.4-15. The applicant characterizes the stream quality as good at the upper reaches and highly degraded at the lower end of the East Branch (ER-OL Section 2.4).

Water quality data at the upper or headwaters station were collected at station E35580 (35.58 km (22.3 miles) upstream of the confluence with the Main Stem of Perkiomen Creek). An overall summary of the data is presented in Tables 4.4 and 4.5. A review of these data indicates that water quality at this station is generally good. The overall average values of constituents and the median values during the low flow periods (i.e., June through November) are within the constituent limitations specified in the Pennsylvania water quality standards. Exceedances of the standards are noted for the maximum recorded values of total iron and ortho-phosphate phosphorus and for the minimum recorded values of dissolved oxygen and alkalinity. Nutrient levels are present in amounts sufficient to cause nuisance conditions if the waters were to be impounded. However, these nutrients--in combination with the flow conditions at this location, and the relatively low concentrations of oxygen-demanding substances--do not result in a depression of dissolved oxygen concentrations below levels supportive of a large diversity of aquatic organisms.

Water quality in the East Branch deteriorates markedly at the intermediate sampling locations, E26700 and E22880 (response to staff question E291.23). Point and nonpoint sources at these locations (e.g., farmland runoff, urban runoff, and sewage from the Perkasie, Sellersville, and Telford areas) result in the highest noted concentrations at station E22880 of all East Branch measurements for some 15 constituent maxima, including biochemical oxygen demand, total dissolved solids, alkalinity, chloride, sulfate, and nitrogen and phosphorus forms, and for 13 constituent mean values, including those mentioned above, with the exception of total dissolved solids. This station had the lowest mean dissolved oxygen concentration of all East Branch sampling locations. Mean ortho-phosphate and ammonia nitrogen concentrations were noted to exceed the Pennsylvania water quality standards, along with the station-recorded maxima for the following eight constituents: total hardness, ammonia nitrogen, chloride, sulfate, nitrate nitrogen, ortho-phosphate, iron, and manganese.

Some improvement in water quality occurs by the time the waters reach the lower East Branch sampling station E2800. All mean and low flow period median constituent values were within the Pennsylvania standards. However, the minimum recorded dissolved oxygen and alkalinity and maximum recorded pH, total hardness, ammonia nitrogen, sulfate, ortho-phosphate, copper, and total iron values exceeded the Pennsylvania standards. Nutrient concentrations remained high, with average phosphate levels about an order of magnitude greater than those of the upper East Branch sampling station. Median nitrate nitrogen concentrations for the low flow periods were about 4 to 5 times the values at the upper stream sampling station, while the overall mean concentration was nearly double the upper stream sampling value. Overall mean ammonia nitrogen remained an order of magnitude above the upper stream concentration. Although median low flow period and overall mean concentrations of chloride and sulfate were not above water quality standards, they were about twice the upper stream station concentrations. East Branch waters at this location remained degraded with respect to the conditions at the upper stream sampling location.

4.3.2.4 Perkiomen Creek

The assessment of the current quality of the waters of the Main Stem of Perkiomen Creek by the Commonwealth of Pennsylvania is the same as that given above for the East Branch of Perkiomen Creek (Penna, 1980). Also the same are the parameter groups judged to be (1) in a degraded condition or (2) exceeding the limitations of the applicable water quality standards and the pollution sources cited as responsible for the degraded conditions.

The designated protected uses for the Main Stem of Perkiomen Creek are the same as for the East Branch; namely, conditions are to be maintained commensurate with a warmwater fishery but with conditions sufficient for the protection of stocked trout for the February 15 to July 31 period.

The applicant collected water quality data from two locations on the Main Stem of Perkiomen Creek, one above and one below the confluence of the East Branch of Perkiomen Creek. The downstream sampling station, P14390, is located at Limerick's Graterford intake location. A seasonal summary of these data for 1975-1978 is in ER-OL Table 2.4-13, and for the period 1979-1982 in an update of this table (response to staff question E291.2). Overall summaries are in Tables 4.4 and 4.5. The applicant characterizes Perkiomen Creek in the vicinity of the Graterford intake as a moderately polluted hard warmwater stream, with essential plant nutrient levels present in high concentrations.

Water quality of the Perkiomen Creek near the Graterford intake is generally good. All seasonal median values as reported by the applicant and all constituent mean values are within the limits established by the Pennsylvania Water Quality Standards. Maximum recorded pH, ammonia nitrogen and total iron concentrations, and minimum recorded alkalinity have exceeded the Pennsylvania standards. The water quality of the Main Stem at this point is generally improved over that recorded for the East Branch at the lower sampling station (E2800). Median low flow period and overall average sulfate and chloride concentrations are about one half the concentrations in the lower East Branch. Nutrient levels are improved somewhat over the lower East Branch, with phosphates lower by a factor of 3 to 4. However, nutrient levels are high compared to the upper East Branch sampling station measurements (E32300)* and those of the Delaware River.

4.3.2.5 Schuylkill River

The assessment of the water quality of the Schuylkill River by the Commonwealth of Pennsylvania for the most recent review period (i.e., 1975-1979) concluded that the river was not expected to meet water quality standards by the end of 1983 (Penna, 1980). Installation of new sewage treatment plants or upgrading/improving existing sewage treatment plants and discontinuing industrial discharges in the stretch of river in the Schuylkill, Berks, and upper Montgomery/Chester County area have resulted in improvements in river water quality for years 1975-1978. However, the Commonwealth cites "inadequately treated industrial and municipal wastes result[ing] in large amounts of oxygen consuming material, nutrients, suspended solids, heavy metals and heated wastes" (ibid.) as the water quality problems in this stretch of the river. Also cited as problems are residual effects of acid mine drainage.

The designated protected water uses for the Schuylkill River are the maintenance and propagation of fish species and additional flora and fauna that are indigenous to a warm water habitat and the passage, maintenance, and propagation of anadromous and catadromous fishes and other fishes that ascend to flowing waters to complete their life cycle (Penna, 1982, Chapter 93).

The applicant has collected water quality data from several locations on the Schuylkill River at the Limerick intake and discharge locations as well as at upstream and downstream locations within the Vincent Dam pool of the river. The applicant characterizes the river near Limerick as having the best quality,

*Median low flow period nitrate concentrations were 3 to 5 times those of the upper East Branch; median low flow period phosphates were an order of magnitude higher than the upper East Branch.

but states that this river stretch suffers from heavy metal contamination, elevated nutrient concentrations from both industrial and municipal waste sources, nutrient and pesticide contamination from nonpoint source runoff, and polychlorinated biphenyl contamination from landfill runoff. Seasonal summaries of Schuylkill River water quality in the vicinity of the Limerick intake for 1975-1978 are presented in ER-OL Table 2.4-12 and are updated for 1979-1982 in Table E291.2 (response to NRC staff question E291.2). Overall summaries of the river water quality in the vicinity of the Limerick discharge are in Tables 4.4. and 4.5.

The water quality data for the Schuylkill River near Limerick indicate that the median and average values for nearly all constituents are in compliance with applicable standards; median and average ortho-phosphate phosphorus values indicate that soluble phosphorus levels are in excess of the water quality standards. Other areas in which applicable standards are exceeded are minimum recorded dissolved oxygen and recorded maxima for constituent ammonia nitrogen, copper, lead, iron manganese, and zinc. For those parameters measured by the applicant during the 1974-1982 period that were also addressed in the FES-CP, the later data show a decrease in all constituent average concentrations. (See Section 5.3.2 for a discussion of water quality impacts associated with discharge from the Bradshaw Reservoir. The staff stipulated on October 19, 1982, to provide such a discussion in the FES.

4.3.3 Meteorology

The discussion of the general climatology of the site and vicinity in the FES-CP remains essentially unchanged. However, the FES-CP did not include a discussion of severe weather phenomena experienced in the region of the Limerick plant. A variety of severe weather phenomena--including thunderstorms, tornadoes, and hurricanes--occurs in the region. About 35 thunderstorms can be expected to occur on about 28 days each year. Hail often accompanies severe thunderstorms. (During the period 1955 to 1967, six occurrences of hail with diameters 19 mm (3/4 inch) or greater were reported in the one-degree latitude-longitude square containing the site. Tornadoes are not uncommon in the region. For a 160.9 km (100-mile) square (2.59×10^4 km^2) (10,000 mi^2) containing the site, an average of about 1.8 tornadoes per year was reported for the period 1953 to 1974. Using an average tornado path area of 7.25 km^2 (2.8 mi^2), the computed recurrence interval for a tornado at the plant site is about 2000 years. The applicant has computed a much longer recurrence interval (about 9000 years) based on a much smaller tornado path area (0.83 km^2) (0.32 mi^2) and a smaller annual frequency (1.2 tornadoes per year). In the period 1871 to 1981, about 15 tropical depressions, tropical storms, and hurricanes have passed within about 80 km (50 miles) of the plant. Wind speeds associated with these storm systems are usually highest along the coast, with wind speeds diminishing further inland.

Since the FES-CP was issued, the applicant has collected additional onsite meteorological data. Wind data taken from the 9.1-m level of the onsite meteorological tower, identified as Weather Station No. 1, for a 5-year period (January 1972 to December 1976) indicate prevailing winds from the west-northwest (13.8%) and northwest (9.6%). Winds from the north-northeast and northeast for this period occurred least frequently, less than 3% of the time. The mean annual wind speed observed at the 9.1-m level of Weather Station No. 1 for the period 1972 to 1976 was about 2.2 m/sec (5 mph), with calm conditions (defined as wind speeds less than the starting threshold of the anemometer) observed almost 18% of the time.

Several different indicators have been used to determine atmospheric stability conditions at the Limerick site. The applicant has used a stability classification scheme based on short-term fluctuations of horizontal wind direction at the 82.3-m level of Weather Station No. 1 and classified into categories based on measurements made at Brookhaven National Laboratory. Based on this stability classification scheme, unstable conditions occurred more than 55% of the time during the period January 1972 to December 1976. Similarly, for the same period of record, neutral conditions occurred about 2.6% of the time, and stable conditions occurred about 29% of the time. The staff has classified atmospheric stability using the vertical temperature gradient measured between the 52.2-m and 7.9-m levels of Weather Station No. 1. Based on this stability classification scheme, unstable conditions (Pasquill types A, B, and C) occurred about 19% of the time for the period January 1972 to December 1976. Similarly, for the same period of record, neutral (Pasquill type D) conditions occurred about 31% of the time, and stable (Pasquill types E, F, and G) conditions occurred about 50% of the time. Of the stable conditions, slightly stable (E) conditions occurred about 32% of the time, moderately stable (F) conditions occurred about 11.7% of the time, and extremely stable (G) conditions occurred about 6.4% of the time.

A complete description of local meteorological conditions, including summaries of onsite data, is presented in both the ER-OL and the FSAR.

4.3.4 Terrestrial and Aquatic Resources

4.3.4.1 Terrestrial Resources

Terrestrial biota of the Limerick site and vicinity are described in Section 2.7.1 of the FES-CP and Section 2.2.1 of the ER-OL. Native vegetation on the site in the vicinity of the cooling towers and reactor building was cleared before the start of construction. The applicant estimates (ER-OL Section 2.2.1) that 32% of the 182-ha (450-acre) Limerick site has been disturbed during construction. At the time of the NRC staff's site visit (August 1982) most of this area remained in a disturbed state because of the continuation of construction activities. Early successional grass and forb species, typical of areas subject to vegetation and topsoil removal, were observed during the site visit. Disturbed areas not needed for parking lots or roadways will be final graded and seeded with perennial grasses once construction is complete.

Mixed deciduous forest stands occur along the Schuylkill River, Possum Hollow Run, and approximately 50 m (164 feet) west of the Unit 1 cooling tower (ER-OL Figure 2.2-1). The various forest types on the site are characterized in Section 2.7.1 of the FES-CP. A fruit orchard is located approximately 700 m (2300 feet) north-northwest of the cooling towers.

The Schuylkill River, forested areas, and cultivated fields in the site vicinity provide habitat for important waterfowl and upland game species. The most common waterfowl species observed during surveys conducted by the applicant were the Canada goose (*Branta canadensis*), mallard (*Anas platyrhynchos*), and black duck (*A. rubripes*). The mallard is a common permanent resident of the area. The ring-necked pheasant (*Phasianus colchicus*), white-tailed deer (*Odocoileus virginanus*), eastern gray squirrel (*Sciurus carolinensis*), eastern cottontail (*Sylvilagus floridanus*), and raccoon (*Procyon lotor*) are the most important upland game species in the Limerick site vicinity.

The staff expects plant and animal species along rural portions of the transmission line corridors to be similar to those in the site vicinity given a similar habitat mix of cultivated fields, forest-edge, and forest. Terrestrial resources along the Limerick-to-Plymouth 230-kV line are somewhat limited in comparison to the other lines because of high residential and industrial development.

4.3.4.2 Aquatic Resources

This section reviews the aquatic resources that potentially will be affected by operation of Limerick station. These resources include four water bodies that will be used for cooling water withdrawal, transport, and effluent discharge: the Delaware River, the East Branch of Perkiomen Creek, the Main Stem of Perkiomen Creek, and the Schuylkill River. The description of aquatic resources includes: those resources that have not been evaluated previously by the staff; those that are related to areas of concern that are new since the publication of the FES-CP in November 1973; and updated information on aquatic resources and on endangered and threatened species.

The FES-CP primarily addressed the potential impacts of station operation on the Schuylkill River and Perkiomen Creek. The impacts associated with diversion of cooling water from the Delaware River through the East Branch of Perkiomen Creek and into Perkiomen Creek were evaluated in the Delaware River Basin Commission's "Final Environmental Impact Statement, Point Pleasant Diversion Plan, Bucks and Montgomery Countries, Pennsylvania" (DRBC, 1973). The FES-CP addressed these diversion-related impacts by reference to the DRBC statement. Similarly, the AEC Atomic Safety and Licensing Board Initial Decision of June 14, 1974 (LBP-74-44), 7 AEC 1098, evaluated the impacts of the heat dissipation system on the Schuylkill River only. That Board found the system environmentally acceptable (pages 1138-1142). The NRC Atomic Safety and Licensing Appeal Board Decision of March 19, 1975 (ALAB-262), 1 NRC 163, found that the FES-CP adequately described the impact of Limerick on aquatic organisms (of the Schuylkill River and Perkiomen Creek) and found that no unusual environmental damage will occur (ALAB-262, page 202). Further, that Appeal Board found the AEC staff's reliance on the DRBC analysis of impacts of the diversion project proper. The AEC staff concurred in the DRBC's ultimate finding that the diversion project would have minimal adverse environmental impact (to the East Branch of the Perkiomen Creek). The Atomic Safety and Licensing Board Special Prehearing Conference Order of June 1, 1982 (LBP-82-43A), 15 NRC 1423, affirmed that the impacts of Limerick on the Schuylkill River and Perkiomen Creek were considered at the construction permit stage (page 1486).

Since the AEC/NRC construction permit proceedings, more information has been collected on the aquatic resources of the Schuylkill River, Perkiomen Creek, and the East Branch of Perkiomen Creek. These data are presented in the ER-OL and in the applicant's updated Environmental Report of July 1979 to DRBC. The following sections of this report update the description of the aquatic resources of Perkiomen Creek and Schuylkill River based on the recent information. The descriptions are brief because the impacts were reviewed previously by the NRC staff and found acceptable. The East Branch of Perkiomen Creek and the analyses were reviewed by the NRC staff, but details were not presented in the FES-CP. The East Branch will be affected by Limerick cooling water diversion; thus a more detailed discussion of the recent data is presented here for completeness and disclosure. The ER-OL contains no information on the aquatic resources of the Delaware River in relation to Limerick cooling water diversion. Data and analyses are in several assessments and studies performed by various organizations and agencies that are cited in the discussion below. This discussion is brief also because the Point Pleasant Diversion on the Delaware River has been reviewed by several agencies, including NRC.

4.3.4.2.1 Delaware River

The Delaware River is a moderate-size warm water river with a drainage area of 30,440 km^2 within New York, Pennsylvania, New Jersey, and Delaware. It originates in the Catskill Mountains of New York and flows for about 530 km before emptying into the Atlantic Ocean at the mouth of Delaware Bay.

Since the FES-CP was issued, the design and location of the Point Pleasant Diversion intake structure have been changed. These changes are described in Section 4.2.4 of this statement. As presently proposed, the diversion is located at Delaware River km 253 (river mile 157.2) about 244 m (800 feet) downstream of the mouth of Tohickon Creek, along the Pennsylvania (west) river bank. The ER-OL contains no aquatic resource information on the Delaware River pertinent to the diversion impact. Data more recent than those in the FES-CP are available, however, in the studies of Smith and Harmon (1974) conducted during July 1972 through December 1973, and in a review of recent studies prepared by Harmon (1980). Several environmental impact assessments of the diversion have been prepared by various agencies and organizations (NWRA, 1979; DRBC, 1980; BCM, 1981; US Army, 1982; Penna Dept. of Environmental Resources, 1982; and NRC ASLB, 1983), several of which draw upon the resource descriptive information in Smith and Harmon (1974) and Harmon (1980).

The studies conducted during 1972-73 encompassed an area about 2 km upstream and 2.4 km downstream of Point Pleasant (Smith and Harmon, 1974). Benthic macroinvertebrates (and drift) and fishes were studied. River habitat in the area consists of riffles, rapids, runs, pools, and backeddies. Tohicken Creek is the only sizable tributary in the area. Periphytic diatoms and filamentous algae (mostly Cladophora) were dominant primary producers. Abundance was light to moderate. Myriophyllum was the most frequently observed rooted macrophyte in the area; it was most common in backeddies.

Macroinvertebrates were sampled qualitatively during July and September 1972 from riffle, run, and pool areas using dip nets and hand removal from substrata. During August 1972 and July to October 1973, invertebrate drift was sampled using stationary fine mesh nets. The Delaware River macroinvertebrate community consisted of all major orders of aquatic insects, annelid worms and leeches, molluscs (snails and clams), arthropod crustaceans, and other phyla. Chironomids (midges) and amphipods (Gammarus sp.) were numerically dominant in dip net samples. The invertebrate drift was dominated by chironomids: 93% of the subsurface and >90% of the surface drift. Sampling occurred less than 3 months after the flood caused by Tropical Storm Agnes (June 1972); thus the results might be characteristic of a benthic/drift community in a post-flood recovery phase.

Sampling also was conducted during August, September, and October 1982 to determine the spatial distribution of Asiatic clams (Corbicula sp.) in relation to the Limerick cooling water withdrawal at Point Pleasant (Kemper, 1983). Collections were made from 35 locations spaced at about 3.2- to 6.4-km (2- to 4-mile) intervals from Point Pleasant (river km 253) downstream to Chester, Pennsylvania (km 142). Samples were collected by pipe dredge in deeper water and by digging with a shovel in shallow water. Corbicula was present in the river from about Trenton, New Jersey (km 220), downstream to the Benjamin Franklin Bridge in Philadelphia (km 169). Corbicula is known to have been in the river near Trenton since 1971 (Crumb, 1977). Between 1971 and 1973, Corbicula increased greatly in abundance there, while the fingernail clam Sphaerium transversum decreased sharply in abundance, perhaps as a result of competition with Corbicula (ibid). Sphaerium and other clam species were collected from the river near Point Pleasant during 1972 (Smith and Harmon, 1974), suggesting that Corbicula could exist there also if it entered the area.

Fishes of the Delaware River were studied during August 1972 through December 1973 (ibid.). Small fishes were sampled by seine, and larger fishes were sampled using fyke and trap nets. Collections were made near Point Pleasant, as well as upstream and downstream in the river. The fish community consisted of 44 species. Small fishes captured by seine were dominated numerically by shiners (87-91% of the annual totals) and sunfishes (3.8-4.1%; primarily bluegill, pumpkinseed, and redbreast). The most productive site in terms of number of species and specimens was a station between the mouth of Tohickon Creek and the present location of the diversion intake, because of the habitat diversity and sheltered areas there. The most abundant species there were shiners (satinfin, spotfin, and swallowtail) and sunfish (bluegill and pumpkinseed). Larger fishes captured by fyke and trap nets consisted of sunfishes (50-51%), catfishes (25-29%), shiners/dace (1-7%), white perch (4-6%), crappies (5%), American eel (3-4%), carp/goldfish (1-3%), white sucker (1-2%), and basses ($\leq$1%). The most frequently captured fishes near Point Pleasant were pumpkinseed and bluegill. Overall, shiners were taken more frequently during spring and late summer through early fall. Sunfishes and catfishes were most abundant during summer and fall. Alewife was the only anadromous species captured (four individuals in June 1973). Studies conducted during 1979 and 1980 have shown that anadromous fishes (American shad, alewife, blueback herring) use the river in the vicnity of Point Pleasant as a nursery area for young-of-the-year that apparently were spawned upriver (Harmon 1980). This stretch of the river apparently has become more important for use by shad in recent years. Although shad are known to migrate through the area to upstream spawning grounds (Smith and Harmon, 1974), the presence of spawning near Point Pleasant was uncertain at the time of the ASLB hearing in October 1982 (NRC ASLB, 1983). The U.S. Fish and Wildlife Service conducted an ichthyoplankton sampling program in the Delaware River at Point Pleasant during April-July 1982. At least 17 species of fish eggs, larvae, and juveniles (plus one adult) were collected (see Section 9 of this FES for details). American shad eggs were collected in small quantities during mid-April through mid-May, while moderate numbers of larvae were captured during latter-May through early-July. Eggs and larvae of other clupeid species (probably alewife and blueback herring) were captured in large numbers throughout May. These data suggest that several species, including anadromous clupeids, utilize the Point Pleasant area for spawning. Although the endangered shortnose sturgeon is present in the Delaware River, none have been captured near Point Pleasant (see Section 4.3.5 below).

These recent studies (since the FES-CP was issued) indicate that the Delaware River near Point Pleasant has a diverse biotic assemblage occupying several river habitat types. The fish community consists of a numerous forage base of small species and a variety of predators. A diverse macroinvertebrate population probably serves as a food base for forage fishes and some predators as well. Rough fishes that are pollution tolerant are relatively low in abundance, suggesting that the riverine environment is not severely pollution stressed. The area serves as a migratory route for anadromous fishes (and perhaps for the catadromous American eel), and serves as nursery grounds also. The variety of other resident fishes suggests that they must use the area for spawning/nursery activities.

4.3.4.2.2 East Branch of Perkiomen Creek

Since publication of the FES-CP in November 1973, more information has been collected on the aquatic resources of the East Branch. These data are presented in Section 2.2.2 of the ER-OL and in the applicant's updated Environmental Report of July 1979 to the DRBC. The East Branch of Perkiomen Creek was studied from 1972 through 1977. Sampling occurred at several locations along the creek, from the headwaters to its confluence with the Main Stem of Perkiomen Creek. The sampling program is summarized in ER-OL Tables 2.2-70 and 2.2-71 and is discussed in ER-OL Section 6.1.1.2.3. Studies were conducted on periphyton, macroinvertebrates and drift, and fishes (larvae, juveniles, and adults). This section will summarize the resources of the East Branch that are relevant to operation of Limerick, based on this new and updated information.

The East Branch of Perkiomen Creek is a warm water headwater stream with a drainage area of about 158 km^2 (61 mi^2). It flows in a southwesterly direction from its headwaters in Bedminster Township for approximately 40 km (25 miles) to its confluence with the Main Stem of Perkiomen Creek south of Schwenksville, Pennsylvania (~creek km 18). The East Branch has a low gradient and consists of a series of riffles, runs, a few shallow natural pools, and several manmade impoundments.

The East Branch can be separated roughly into three ecological sections based upon physical characteristics, nutrient loading and water quality, and biotic composition. The upper section of the East Branch (~12-13 km in length, upstream of Sellersville, Pennsylvania) is a series of runs and riffles with some slow moving sections. During low flow seasons, the riffle habitat is much reduced and the upper section consists of a series of isolated or nearly isolated shallow pools, some containing abundant aquatic vegetation. The middle section of the East Branch (~15-16 km in length, from about Sellersville to about Bergey, Pennsylvania) is characterized by riffles, runs, a wider stream width, and several low impoundments of quiet water. A diversity of habitat types is present; however, agricultural runoff and treated sewage effluent (at about km 23 on the creek) enter the creek here, creating degraded water quality conditions. The lower section of the East Branch (~12 km long, to the confluence with the Main Stem of Perkiomen Creek) contains riffles, runs, fast moving water, and at least one impoundment. Nutrient loading to Indian Creek (which enters the East Branch in this section) periodically degrades the water quality. Water quality is somewhat better than in the middle section.

Biota of the East Branch exhibit longitudinal difference in species composition, abundance, and diversity as a result of seasonally variable stream flows, habitat types, and degraded water quality in the middle and lower sections of the stream. Some of these differences serve as useful bioindicators of the present stream condition that can be compared with future conditions during the operation of Limerick station.

Periphyton of the East Branch was studied during 1973 and 1974 using artificial substrate samplers. Periphytic algae predominantly were diatoms that were most abundant during April through October. Biomass was greatest during summer as a result of stable low stream flow and warm water temperature. During periods of low flow, biomass was greater at sampling stations in the upper and middle sections than in the lower section of the creek, probably as a result of shallower water with more light penetration. Periphyton in the upper section was more susceptible to scouring during increased flow than periphyton in the lower section where the creek is wider and velocity is less.

Macroinvertebrates of the East Branch were studied during 1973, 1974, and 1976 at about 6-km intervals along the length of the creek using net samplers. Only riffle habitats were studied because of their prevalence in the system and the high biotic diversity and production typical of that habitat type. The East Branch macroinvertebrate assemblage is diverse and consists of aquatic insects and other anthropods (isopods, amphipods, decapods,i.e., crayfish), planarians, annelids (leeches, worms), molluscs (snails, clams), and others. Abundance generally increases from spring through summer and peaks during fall (September). Longitudinal changes in the macrobenthos are evident and result from intermittent and variable flow in the upper section and degraded water quality in the middle section of the creek. The number of taxa (4-year mean) is greatest in the upper section, decreases in mid-creek downstream of Sellersville, and increases with distance into the lower section.

Dominant invertebrate taxa of the East Branch have been identified based on numerical and biomass abundance (ER-OL Section 2.2.2.2.6.3). Several of the species and taxon groups are useful indicators of environmental conditions of the creek, especially with respect to water flow and water quality changes between the headwaters and the lower creek sections (Table 4.6). Diversion of water from the Delaware River into the East Branch can be expected to affect the creek invertebrate community as a result of: (1) water volume increase, especially during normally low flow seasons; (2) reduction in flow variability, thus a more stable physical environment; (3) improvement in water quality in middle and lower sections as a result of dilution with diversion water; and (4) potential introduction into the creek of species from the Delaware River. These effects likely will be most evident by changes in the abundance and distribution of the indicator species. Because the invertebrate community serves as a food base (along with the periphyton and other aquatic plants) for the creek fish community, changes resulting from diversion of water also could affect the fishes.

Fishes of the East Branch were studied during 1973 through 1976. Drifting eggs and larvae were sampled during 1973 and 1974 in the lower creek section. Small fishes and young of larger species were sampled by seine during 1975 and 1976 at eight locations throughout the length of the creek. Juvenile and adult fishes were sampled by electroshocking during 1973, 1974, and 1975 at five lotic (flowing) sites spaced throughout the creek and two pond sites in the lower section. The creek fish community is a warmwater assemblage of 40 species plus a few hybrids, and 2 species (brook trout and muskellunge) that have been stocked occasionally in the East Branch of Perkiomen Creek. The community is dominated by shiners and minnows, catfishes, suckers, and sunfishes. Catches of drifting larvae in the lower creek section indicated that spawning occurred during May through August. The peak spawning of white sucker, tessellated darter, and carp occurred during May. Minnows spawned throughout the period, with several peaks

Table 4.6 Representative invertebrate bioindicators of environmental conditions in the East Branch of Perkiomen Creek

Invertebrate Taxa	Environmental Conditions and Taxa Status
Oligochaete worms	Naidids and tubificid worms present throughout creek, but dominant in middle section; pollution tolerant.
Leeches	Present in low numbers throughout creek; dominant only near Sellersville; pollution tolerant.
Crayfish	Found principally in headwater area; prefer riffle habitat; discontinuous flow during 1973-74 contributed to increased densities in upper section.
Stoneflies	_Allocapnia_ sp. and _Perlesta_ sp. present principally in headwater area; tolerant of intermittent flow.
Caddisflies	_Hydropsyche_ sp. essentially absent in headwater area (of discontinuous flow) and in area immediately downstream of Sellersville (with degraded water quality); abundant in other areas.
Micro-caddisfly	_Leucotrichia_ sp. essentially absent from upper and middle creek sections; dominant in lower section; intolerant of organic pollution.
Cranefly	_Tipula_ sp. most abundant in upper section.
True midges	The most diverse invertebrate group in the creek; some species abundant in upper section others in middle and lower sections; some species tolerant of organic enrichment and low _DO_, others tolerant of intermittent flow.
Snails	_Physa_ sp. present throughout creek, but most abundant in middle section; maximum density during summer and fall, perhaps because of seasonally abundant periphyton food source.
Fingernail clams	_Sphaerium_ sp. present throughout creek, but most abundant in middle and lower sections; young most numerous during summer and fall; abundance has increased significantly between 1972 and 1976 in middle and lower sections; pollution tolerant.

Source: ER-OL Section 2.2.2

evident. Shiners spawned during May and June. Yellow bullhead and sunfishes spawned principally during June and July, with some sunfish spawning into August. Few drifting eggs were caught because most East Branch fishes deposit demersal eggs.

Longitudinal changes in the composition of the fish community occur between the headwaters and the confluence of the East Branch and the main stem of Perkiomen

Creek, as a result of habitat differences, flow differences, and water quality degradation in the middle and lower sections. The number of fish species increased from the headwater area (19 to 22 species) into the middle section (22 to 25 species), and decreased downstream (21 to 22 species). Several species are useful indicators of environmental conditions of the creek, especially with respect to: water flow; habitat variety; water quality; and perhaps food availability, competition, and interspecies breeding (hydridization) in the headwater areas. The ER-OL highlights the discussion of 11 species as "important" because of ecological status, sociological importance, and potential for impact from diversion of water into the East Branch. The hybrid sunfish (Lepomis spp) could be added to this list because of its unusual prevalence in the upper creek section. Table 4.7 summarizes a cross-section of fishes useful as indicators.

Table 4.7 Representative fish bioindicators of environmental conditions in the East Branch of Perkiomen Creek

Fish Taxa	Environmental Conditions and Taxa Status
Redfin pickerel	Found principally in the upper section near and downstream of diversion inflow (~creek km 36); prefer slow shallow pools with aquatic vegetation.
Satinfin shiner	Absent upstream of Sellersville; prefer moderate to rapid current in shallow areas without much aquatic vegetation.
Common shiner	Most abundant in upper section; least abundant at Sellersville, probably because of degraded water quality.
Spotfin shiner	The most abundant species creek-wide in seine catches; more abundant upstream of Sellersville, but common downstream as well; weight-length regression and distribution suggest a tolerance to degraded water quality.
White sucker	Present throughout creek; young least abundant near Sellersville; adults most abundant near Sellersville; fish downstream of Sellersville consistently larger at each annulus for all ages (1 to 4 years) than fish upstream; abundant in ponds; upstream fish have better condition factor; pollution tolerant.
Yellow bullhead	Present throughout the creek; most abundant in lower section and in pond there; an important pan fish of the East Branch.
Redbreast sunfish	Young fish most abundant in upper section, least abundant near Sellersville; adults most abundant in upper section, least abundant near Sellersville, common in lower section; the mean length of fish at each annulus for ages 1 to 4 years progressively increased with distance downstream from the headwaters, probably because of reduced competition and increased habitat variety and space downstream.

Table 4.7 (continued)

Fish Taxa	Environmental Conditions and Taxa Status
Green sunfish	Present throughout creek; adults most abundant near and downstream of Sellersville; abundant in middle and lower section ponds; pollution tolerant.
Pumpkinseed	Most abundant upstream of Sellersville; common in middle and lower section ponds; prefer quiet water habitat.
Smallmouth bass	Abundant only in extreme lower section near confluence; least abundant near Sellersville; most specimens collected were young; lack of upstream flow and habitat and degraded water quality limit production.
Tessellated darter	Abundant upstream of Sellersville; adaptable to a variety of habitat types including quiet water and riffles; intolerant of poor water quality.
Hybrid sunfish	Progeny of interspecies mating of two or more sunfishes (Lepomis sp); unusually abundant in headwater area near and downstream of diversion inflow; hybridization probably the result of crowding of fish in isolated pools during the spawning season (June-August) when flow is low and intermittent.

Source: ER-OL Section 2.2.2

4.3.4.2.3 Perkiomen Creek

The Main Stem of Perkiomen Creek is a warm water stream with a drainage area of about 938 km^2. It is a major tributary to the Schuylkill River at about river km 20 (mile 32.3) in Montgomery County. The East Branch meets the Main Stem at about 18 km upstream of the confluence of the Main Stem of Perkiomen Creek and the Schuylkill River (Figure 4.5). The Limerick cooling water intake at Graterford is located at km 14.4 of the Perkiomen Creek. Cooling water diverted from the Delaware River will enter Perkiomen Creek (via the East Branch) at km 18 and be withdrawn at Graterford, about 3.6 km downstream.

Since the issuance of the FES-CP, studies have been conducted on aquatic resources of Perkiomen Creek in the area to be utilized for transport and withdrawal of diversion water. These data are presented in Section 2.2.2 of the ER-OL and in applicant's updated Environmental Report of July 1979 to the DRBC. The creek was sampled for aquatic biota at several locations between about km 13.6 and km 22 from 1972 through 1976. The sampling program is summarized in ER-OL Tables 2.2-40 and 2.2-41 and is discussed in ER-OL Section 6.1.1.2.2. Studies were conducted on phytoplankton, periphyton, benthic macroinvertebrates and invertebrate drift, and fishes (larvae, juveniles, and adults).

Periphyton was studied during 1973 using artificial substrate samplers. Periphytic algae were almost exclusively diatoms. Maximum biomass and production rate occurred during October. Phytoplankton was studied during 1973 and 1974 using plankton nets and sampling bottles. Diatoms and green and blue-green algae of 54 species were collected. Most phytoplankters were of periphytic origins. In general, densities were low and seasonal successions followed changes in creek water temperature.

Benthic macroinvertebrates were studied using net samplers during 1973, 1974, and 1976 at two stations, one 4 km upstream of the East Branch and Main Stem confluence, and one about 0.8 km downstream of the Graterford intake area. All sampling was of riffle habitat because it is common and because production is high in this habitat type. The Perkiomen Creek macroinvertebrate assemblage is diverse and productive, consisting of aquatic insects and other arthropods (isopods, amphipods, decapods-crayfish), plenarians, annelids (leeches, worms), molluscs (snails, clams), and others. Total numbers and biomass were greatest during fall. In terms of species composition and abundance, the two stations on the Perkiomen Creek were more similar than were any two stations on the East Branch, probably because of the greater variation in flow, water quality, and habitat types along the East Branch. More total species were collected from each station of the Perkiomen Creek than at any sampling station on the East Branch. Some differences in species types and abundance were evident, however. For example, dobsonflies (Corydalus sp.) and the mayfly (Ephemerella sp.) were rarely taken in the East Branch, but were numerous in Perkiomen Creek. Fingernail clams (Sphaerium sp.) were present in both creeks, but were considerably more abundant in the East Branch. Crayfishes were more abundant in the East Branch, especially in the upper section. Cambarus sp. was found only in the East Branch, while Orconectes sp. was present in low abundance at most stations. Benthic drift consisted mostly of insects in both creeks and was more abundant in the Main Stem of Perkiomen Creek than in the East Branch.

Fishes of Perkiomen Creek were studied during 1973 through 1976. Drifting larvae were studied during each year near the Graterford intake area. Small fishes were sampled by seine and electrofishing during 1975 and 1976. Large fishes were sampled by electrofishing during 1974, 1975, and 1976. Small and large fishes were sampled near, upstream of, and downstream of the Graterford intake area. The Perkiomen Creek fish community consists of 40 species, 2 hybrids, and 1 rare species (Fundulus heteroclitus), possibly introduced as a bait release. The community is dominated by shiners, sunfish, sucker, smallmouth bass, and carp. Drifting larvae were present from May through August and consisted of minnows, carp, white sucker, yellow bullhead, rock bass, sunfishes, tessellated darter, and shield darter. Abundance peaked during May through mid-June, with most species having densities less than 0.1 larvae/m^3. Carp were most abundant (May 1974; 7.3/m^3), followed by minnows (May 1974; 0.6/m^3), sunfishes (June 1974; 0.3/m^3), and white sucker (May 1975; 0.2/m^3).

Section 2.7.2 of the FES-CP briefly discussed the aquatic biota of Perkiomen Creek, and Appendix C provided general life history information on important fishes. The data collected during 1973-1976, as presented in the ER-OL, are considerably more detailed than the FES-CP discussions and concentrate on organisms potentially to be impacted by operation of Limerick. There appear to have been no significant changes in the biotic community of Perkiomen Creek since the previous assessments that affect or alter the previous conclusions. The more detailed recent information permits a narrowing of focus to identify the species at risk. For example, larval fish studies indicate that carp, minnows, and sunfishes are most abundant near the Graterford intake, and, therefore, most susceptible to water withdrawal impacts. Although the newer data do not indicate significant biotic differences, the previous NRC staff conclusions on impact could be altered as a result of the change in the design of the Graterford intake structure from travelling screens (addressed in the FES-CP) to wedge-wire screens (described in the ER-OL). This is examined in Section 5.5.2 of this report.

4.3.4.2.4 Schuylkill River

The Schuylkill River is a small warm water river with a drainage area of 4972 km^2. It originates in Schuylkill County, Pennsylvania, and flows southeasterly for 209 km (130 miles) to its confluence with the Delaware River at Philadelphia. Limerick is located at about river km 78 (mile 48.5). Preexisting stresses to the river include environmental degradation from: mine wastes; sewage effluent and nutrient loading from nonpoint source runoff; pesticide, PCB, heavy metal, and oil contamination; frequent flooding; and several dams (five between Limerick and the Delaware River) that prevent fish migrations and alter habitat and flow conditions.

Since the FES-CP was issued, studies have been conducted on aquatic resources in a 10-km stretch of the river from Vincent Dam (km 72) downstream of Limerick to an upstream point at about river km 82. Sampling was conducted during 1973 through 1978 for phytoplankton, periphyton, macrophytes, benthic macroinvertebrates and invertebrate drift, and fishes (larvae, juveniles, and adults). The data are presented in Section 2.2.2 of the ER-OL. The sampling program is summarized in ER-OL Tables 2.2-7, -8, and -9 and is discussed in Section 6.1.1.2.1.

Phytoplankton and periphyton were studied during 1973 and 1974 via water bottle grab samples and artificial substrates respectively. Sixty-eight genera of phytoplankton were collected, consisting of diatoms and green and blue-green algae. Seasonal succession of groups occurred, with diatoms dominant during the spring, green algae abundant in the summer, and blue-green algae most numerous during the fall. Phytoplankton probably does not have a significant role in the trophic structure of the river. Periphytic algae is a seasonally important primary producer in the river. Productivity was highest during summer and fall when river velocity, flow, and turbidity are low. Diatoms dominated the periphytic algae, followed by green algae and one species of blue-green algae.

Aquatic macrophytes were studied during 1974 and 1977 in a 3.6-km stretch of the river upstream and downstream of Limerick. Surveys were made by boat and by aerial photography, and macrophyte beds were mapped (ER-OL Figure 2.2-4). Species and abundance also were noted during sampling for fishes. Ten species were observed, with submergent forms dominant. Peak growth was during the summer of 1977 when 20 to 25% of the river surface area was occupied by macrophyte hammocks of several rooted vascular species, principally pondweed (<u>Potamogeton</u> spp), water stargrass (<u>Heteranthera</u> sp), and water milfoil (<u>Myriophyllum</u> sp). During the 1975-1977 fish sampling period, macrophytes were noted to have been common-to-abundant from about 400 m (0.25 miles) upstream of the intake to about 400 m downstream of the discharge. The attached green alga <u>Cladophora</u> was abundant and ubiquitous throughout the river near Limerick. The macrophyte beds provide important habitat in the Schuylkill River near Limerick for numerous invertebrates (e.g., insects and snails) and for epiphytic algae, and provide cover for many fishes. The FES-CP (Section 2.7.2.2) stated that the algal community had not been studied near Limerick and that extensive macrophyte populations did not occur there. The recent studies have filled this gap and show that submergent vascular plants are an important component of the aquatic community near Limerick.

Benthic macroinvertebrates were studied using cylindrical colonization samplers placed into the river bottom at several stations along transects running perpendicular from shore toward mid-river. Three transects were studied (one upstream of Limerick and two downstream) during 1973 through 1976. All of the transects were in run-rubble habitat that predominates. Invertebrate drift was sampled during 1973 through 1975 near the Limerick intake area (river km 77.6) using plankton nets affixed to frames anchored to the river bottom. The nets projected slightly out of the water to collect surface drift. The Schuylkill River macroinvertebrate assemblage is diverse and numerous (at least 297 species)--including all major orders of aquatic insects, annelids, molluscs, arthropod crustaceans, and several other phyla. Numerically dominant taxa were tubificid worms (Limnodrilus sp.), chironomids (midges), snails (Goniobasis sp. and Physa sp.), and caddisflies (Cheumatopsyche sp.). Since 1972, the snail Goniobasis virginica has moved progressively upstream, and since 1973 has comprised over 90% of the total biomass in many samples, especially at downstream stations. Benthic macroinvertebrates are an important component of the aquatic community and play a significant role in the trophic structure of the river, as browsers and grazers (snails), predators (crayfishes), and prey for other invertebrates and fishes. The invertebrate drift was dominated overwhelmingly by chironomids of species also dominant in the benthos. Densities were high during April through September. The percentage of benthic organisms present in the drift at any given time was very low (0.0002 to 1.340%). The ER-OL presents a discussion (Section 2.2.2.1.6.3) of important or indicator invertebrates of 17 taxa including a planarian, one nemertian, two annelids, seven arthropod groups, four snails, and two clams. The FES-CP discussed the river benthic macroinvertebrate community in Section 2.7.2.3. Since that time, changes have occurred in the abundance and distribution of several species (such as for Goniobasis, above). Tropical Storm Agnes in June 1972 created a record flood and initiated an oil spill in the river, both of which contributed to changes in the abundance and distribution of many river invertebrate species. The studies conducted since the FES-CP provide updated information and reaffirm the importance of the benthos to the river system near Limerick.

The most significant change related to the operation of Limerick could be the discovery of Asiatic clams (Corbicula sp.) in the Schuylkill River during the summer and fall of 1982 (Kemper, 1983). Sampling was conducted at 19 locations at 2 to 4-mile (3.7 to 7.9-km) intervals between Limerick and the confluence with the Delaware River. Corbicula was present from just upstream of the Norristown Dam (river km 15) to just downstream of the Fairmont Dam in Philadelphia (km 5). It seems unlikely that Corbicula would progress upstream over both Black Rock and Vincent Dams and become established near Limerick. Its presence at downstream areas and the presence of other clam species (Pisidium and Sphaerium) at upstream locations suggests that the river near Limerick could provide suitable habitat for Corbicula, should it become introduced into the river there by some means.

Fishes of the Schuylkill River were studied during 1973 through 1978. Drifting larvae were studied during 1974-1976 near the cooling water intake (river km 77.56) using plankton nets and larval fish traps. Hand-held push nets were used to sample fish larvae near shore at three sites within about 1.4 km upstream of Limerick and at 10 sites within about 2 km downstream. Small fishes were sampled during 1975-1976 by seine at 11 sites, 5 upstream and 6 downstream of Limerick. Population estimates of small fishes were produced based upon electrofishing at several sites upstream and downstream of the intake and discharge area during 1973-1976. Large fishes were sampled by electrofishing for population estimates, catch-per-effort, and for age and growth during various years between 1973 and 1978. Sampling sites were located from about 2 km upstream to 5 km downstream of Limerick. Trap netting was conducted in the Vincent Pool (formed by Vincent Dam at river km 72) during 1973-1976 for species important as forage for sport fishes and species sought by anglers. The Schuylkill River fish community consists of 42 species plus at least 2 hybrids. Twenty-seven species are native, and 15 have been introduced. Dominant species (numerically) were similar to those discussed in the FES-CP: shiners of several species; banded killifish; white sucker; sunfishes (redbreast, green, and pumpkinseed); goldfish; and brown bullhead. The abundance of swallowtail shiner (the most numerous species) peaked during fall and winter, with the number lowest during late spring to early summer. Numerically, the most species were collected during winter aggregation periods and after late spawns in the fall, with peaks occurring in areas of dense macrophytes or in spawning or nursery areas.

The most abundant species in the vicinity of the Limerick intake and discharge during 1973-1976 were swallowtail and spotfin shiners, redbreast sunfish, pumpkinseed, white sucker, brown bullhead, and goldfish. The recent studies show that redbreast and pumpkinseed are numerous throughout the study area, while smallmouth bass are uncommon and collected only in small numbers at any station. Diseases, wounds, parasites, and abnormalities were common among several Schuylkill River fish species: goldfish (43% of fish exhibited some symptom); pumpkinseed (11%); brown bullhead (8.6%); white sucker (8.3%); redbreast sunfish and largemouth bass (2% each). This probably is indicative of the degraded condition of the aquatic environment. Fishes that may be weakened by disease conditions could be susceptible to impact from Limerick operation, especially those species that are common near the station. Impingement sampling at the Cromby generating station (located about 12 km downstream from Limerick) collected primarily brown bullhead (44% of the total) and white sucker (16%) (LaBuy, 1978). Total impingement was low (573 fish) at a water withdrawal rate of about 500 ft^3/s (compared with ≤ 94 ft^3/s for Limerick). This suggests, however, that brown bullhead and white sucker could be susceptible to impingement at Limerick also.

Larval fishes were present from late April through early September, with peaks in abundance during June and July. Twelve species were identified, plus unspeciated groups of <u>Lepomis</u> spp. (sunfishes) and minnows/shiners. The most abundant species overall in the vicinity of the Limerick intake were goldfish (peak mean 24-hour density of 8.5 larvae/m^3), minnows (0.7/m^3), carp (0.5/m^3), and <u>Lepomis</u> spp. (0.2/m^3). The abundant species occurred throughout the study area. Goldfish and <u>Lepomis</u> spp. tended to be more numerous downstream of Limerick than upstream. Densities generally decreased with increasing distance from shore. Spawning occurs throughout the area, especially in macrophyte beds and in tributary creeks. The area in the immediate vicinity of Limerick does not appear to be unique with respect to fish spawning and nursery activities. Larvae of smallmouth and largemouth bass rarely occurred in the drift and were not reported in the tabular data of the ER-OL. Fish eggs were collected periodically during May through August, with maximum abundance of about 0.2 eggs/m^3.

Ichthyoplankton sampling at Cromby generating station produced 2585 larvae, of which 76% were goldfish and 10% were carp (ibid.). Changes in the fish community since the FES-CP was issued appear to be related to natural shifts in relative abundance and distribution within the study area. The June 1972 flood generated by Topical Storm Agnes affected some species, such as brown bullhead, which suffered virtual failure of the 1972 year class.

The recent information provided in the ER-OL presents a much more detailed picture of the fish community of the Schuylkill River than is evident in the FES-CP. The river throughout the study area provides habitat for a variety of fishes. Degraded water quality contributes to growth of aquatic macrophytes that provide shelter, food, and spawning habitat for fishes. A degraded environment also contributes to an abundance of pollution-tolerant fish species (goldfish, carp, white sucker, etc.) and to a high incidence of diseases among several species discussed above. The picture presented is one of a stressed system with a potential for recovery.

4.3.4.2.5 Fisheries

This section addresses uses of the fishery resources of the water bodies potentially impacted by operation of Limerick. These were not discussed in any detail in the FES-CP. The main area of potential impact is the Schuylkill River, which serves as both source and receiving waters for station operation. Information on angler use and harvests within a few km upstream and downstream of Limerick have become available since the FES-CP was issued. These data describe the river fishery as local. Data also are presented on harvests downstream of Limerick and for the Delaware Bay, where effluents will travel and might be bioaccumulated and enter the food chain leading to humans. Also discussed are fishery resources of the water bodies that will provide makeup and transport of supplemental cooling water from the Point Pleasant Diversion.

Delaware River

The river in the vicinity of Point Pleasant supports a panfish and centrarchid population that provides good sport fishing throughout the spring, summer, and fall months (Penna, 1982). Additionally, the area supports good bank fishing for American shad. The Point Pleasant area has been described as one of the six best shore fishing sites on the Pennsylvania side of the river between Trenton and Easton, and the second best spot for shore fishing for shad in that area (NRC ASLB 1983, 128 at 88). At Point Pleasant, the shad migratory path is sufficiently close to shore so that fishermen can cast into it from the Pennsylvania river bank (NRC ASLB, 1983, 129 at 88). Data on shad harvest based on the results of angler surveys conducted in the river encompassing the Point Pleasant area are given in Table 4.8 (Miller et al., 1982).

Surveys conducted in 1974 estimated that fishing pressure was approximately 72,000 angler-days of effort for shad in the Delaware River, resulting in approximately 0.6 shad per trip. The recreational demand for shad is expected to increase in the future as it has in the past as a result of the development of access and recreation areas along the river and of increasing populations in nearby metropolitan areas (ibid.).

There is commercial fishing for shad in the tidal portions of the Delaware River and in Delaware Bay by fishermen in New Jersey and Delaware. During the

Table 4.8 Shad harvest in Point Pleasant area

Area studied	Year	Number of fishing trips	Total no. of shad caught	No. shad caught per trip
Scudders Falls into the East Branch	1965	>54,000	5,318	0.1
Trenton, NJ to Damascus, PA	1971	50,000	25,000	0.5

period 1972 to 1978, landings ranged between 12,494-64,287 kg (27,544-141,726 lbs), and values ranged between $2,601-28,970 (ibid.).

Delaware Bay

Recreational fish and shellfish harvests for Delaware Bay have been approximately 3-4 million kg (Table 4.9), while commercial harvests have been approximately 1.3-2.4 million kg (Table 4.10).

East Branch and Main Stem of Perkiomen Creek

Important recreational fishes of the East Branch of Perkiomen Creek include catfish (especially yellow bullhead), the pike family (mostly redfin pickerel), sunfishes, and smallmouth bass (ER-OL Section 2.2.2.3.7). Recreational fishes of Perkiomen Creek include the pike family, sunfishes, smallmouth bass, and carp (ER-OL Section 2.2.2.7). Estimates of harvest levels and fishing effort are not available. Commercial fishing does not exist in either creek.

Schuylkill River

A roving creel survey of anglers fishing the river was conducted during June through early September 1976 (Harmon, 1978). The study was conducted in a 1.6-km area upstream of Limerick near Sanatoga (river km 79 to 80.6) and in a 4.6-km stretch of the river downstream of Limerick near the Vincent Dam and Linfield (km 70.8 to 75.4). Virtually no public access to the river exists in the 3.6-km stretch from just upstream of Linfield Road Bridge to just downstream of Sanatoga Road Bridge. Limerick is located in this stretch of the river at about km 78. Fishing is one of the most important recreational uses of the river. Bank fishing predominates. Twenty-five taxa of fish were caught, with sunfishes representing 57 to 72% of the total, followed by catfishes (18%, mostly brown bullhead), carp/goldfish (4 to 13%), American eel (2%), smallmouth bass (1 to 3%), and others. The mean catch and harvest rates were as shown in Table 4.11.

The anglers interviewed ranged in age from 5 to 77 years, with most (67%) over the age of 15 and requiring a state fishing license. About 35% of the survey respondents fished the river once a week or more often in the summer. A majority of the anglers lived within 15 km of the river; only about 10% traveled more than 15 km to fish there. About 63% of the anglers stated that they fished the river for recreation (Harmon, 1978). Fishing for food apparently was of lesser importance. The low retention rates (percentage of the fish caught that were kept) of about 15 to 16% attest to this.

Table 4.9 Recreational fishery harvest for Delaware Bay from about Artificial Island and south to the ocean (state of Delaware waters only)

Harvest	Kg	Lb
1974		
Weakfish	1,600,000	3,500,000
Bluefish	227,000	500,000
Shark	84,000	190,000
Flounder (summer)	69,500	153,000
Other fish	227,000	500,000
Total fish	2,207,500	4,843,000
Hard clam	1,000,000	2,200,000
Soft clam	820,000	1,800,000
Total clam	1,820,000	4,000,000
1974 Total	4,027,500	8,843,000
1977		
Total	3,400,000	7,500,000

Source: Hope Creek ER-OL, March 1, 1983 (Section 2.1.3.5).

Table 4.10 Commercial fishery harvest for Delaware Bay from about Artificial Island and south to the ocean, kg

Year	Finfish	Shellfish	Total
1976	236,985	1,424,297	1,661,282
1977	360,248	941,960	1,302,208
1978	376,548	1,222,486	1,599,034
1979	479,970	1,202,373	1,682,343
1980	1,070,895	1,310,924	2,381,819

Source: Hope Creek ER-OL, March 1, 1983 (Table 2.1-13)

Table 4.11 Schuylkill River catch and harvest rate

Area	No. of fish caught/rod hr	No. of fish kept/rod hr	Retention rate, %
Upstream	1.16	0.18	15.3
Downstream	0.89	0.15	16.6

Source: Harmon, 1978

A creel survey conducted during 1980 and 1981 covered an entire 8.6-km stretch of the river bracketing the Limerick site from downstream at about the Vincent Dam to the railroad bridge near Sprogles Run upstream (ER-OL, Revision 9, response to NRC staff question E291.16). Anglers were concentrated upstream near Sanatoga and downstream at the Linfield Bridge and the Vincent Dam tailrace. Virtually no fishing was observed near Limerick. Estimates of total angler hours of fishing effort for the survey area were 10,009 hours in 1980 (May to September) and 11,645 in 1981 (March to September).

An estimated 1,495,000 hours of fishing effort were expended during 1975 in the 80 km of the river downstream of Limerick (essentially the whole river to its confluence with the Delaware River). The estimated edible fish catch was 27,500 kg (ER-OL Section 2.1.3.6 and Table 2.1-43).

The Pennsylvania Fish Commission has begun a program to restore anadromous fishes to the Schuylkill River (personal communication between Michael Kaufman, Area Fisheries Manager, Pennsylvania Fish Commission, Coopersburg, and C. Hickey, NRC). The present effort is concentrated on American shad that tentatively are to be stocked (as fingerlings) into the river between Pottstown and Reading during the summer of 1983. The restoration program includes installation of fish passage facilities at the mainstream dams to permit anadromous fishes access to and from upstream spawning and nursery areas. The Fairmont Dam in Philadelphia (river km 13.7) is the first of six dams to have an operational fishway. It permits access upstream to the next dam (Flat Rock Dam at km 25.1) that does not yet have a fishway. The Fairmont Dam fishway is being used by shad, white perch, river herring (alewife), eels, and other resident species. Tentatively, shad will continue to be stocked into the river until all six dams have been installed with passage facilities.

4.3.5 Endangered and Threatened Species

4.3.5.1 Terrestrial

No Federally endangered or threatened species are known to inhabit the site vicinity, along the proposed transmission line routes, or along the cooling system makeup water route from the Point Pleasant Pumping Station on the Delaware River to the Limerick site. Using the Pennsylvania State Game Commission's computerized fish and wildlife data base, the staff determined that two state endangered species are known to occur in Montgomery County. These are the bog turtle (Clemmys muhlenbergii) and the New Jersey chorus frog (Pseudacris triseriata kalmi). The applicant did not observe either species on site. No surveys were conducted by the applicant along the makeup water route in Perkiomen Creek or at the Point Pleasant Diversion site on the Delaware River. An additional state endangered species, the eastern mud turtle (Kinostermon s. subrubrum) occurs in Bucks County (McCoy, 1982), but its distribution is in the extreme southeastern portion of the county downstream of the Point Pleasant Diversion.

The staff has reviewed the applicant's data from onsite vegetation surveys reported in Section 2.2.1.1 of the ER-OL. In comparing the data with the Federal list of endangered and threatened plants published in the Federal Register (Vol 45, No. 242, December 15, 1980) the staff concludes that no protected plant species occur on the site. One endangered orchid species, the small whorled pogonia (Isotria medeoloides) is known to occur in mixed oak forest stands in Montgomery County (Weigman, 1979). No specific data were available, however, on the occurrence of protected plant species along the proposed transmission line corridors based on surveys. The applicant stated that investigations of the Limerick transmission line corridors revealed no listed or proposed Federally threatened or endangered plant species (ER-OL, response to NRC staff question E290.1, Revision 1).

4.3.5.2 Aquatic

Shortnose sturgeon, Acipenser brevirostrum, is on the list of endangered species maintained by the U.S. Department of the Interior Fish and Wildlife Service. It occurs in the Delaware River, from which supplemental cooling water for Limerick will be withdrawn, but does not occur in any of the other three water bodies potentially affected by Limerick operation. In the Delaware River drainage area, it is known to occur in the upper Delaware Bay, in the upper tidal portion of the river to Trenton, and upstream of the fall line as far as Lambertville, New Jersey (river km 240) (NUREG-0671; Brundage, 1982a and b; Brundage and Meadows, 1982; and Nat'l Marine Fisheries, 1982). Shortnose sturgeon has not been captured upstream of Lambertville and does not occur near Point Pleasant (river km 253). No critical habitat has been designated in the area (Brundage and Meadows, 1982).

4.3.6 Community Characteristics

The socioeconomic descriptions of the area--including demography, land use, and community characteristics in general--are in Chapters 2, 4, 5, and 12 of the FES-CP. The Limerick site, located on the border of Montgomery and Chester Counties, Pennsylvania, is transversed by the Schuylkill River. It is about 6.4 km (4 miles) southeast of Pottstown (1980 population 22,729). The nearest city limits of the City of Philadelphia (1,688,210) are about 34 km (21 miles) to the southeast. The applicant developed population data within 16.1 km (10 miles) of the plant by meter counts (ER-OL Table 2.1-2). The staff has compared the applicant's data, shown in Table 4.12, with other sources and with maps and aerial photographs and found them to be reasonable. The area within 16.1 km experienced a decrease in population of 4.2% from 1970 to 1980. For population data from 16.1 to 80 km (10 to 50 miles) from the site, the staff is using a computerized population allocation model based on 1980 census data.

These estimates are shown in Table 4.13. The applicant's data for these areas were examined and found to be consistent with the staff's estimates. The area within 80 km experienced a decrease in population of less than 0.2% between 1970 and 1980.

Table 4.12 1980 population distribution 0-10 miles from the site*

Sector	Distance (mi) 0-1	1-2	2-3	3-4	4-5	5-10	10-mi total
N	58	682	894	397	753	3158	5942
NNE	46	1088	244	478	204	2428	4488
NE	46	40	202	334	276	3732	4630
ENE	12	58	199	380	228	5139	6016
E	20	150	271	389	418	5120	6368
ESE	29	179	297	268	579	9223	10575
SE	6	369	141	4844	4055	6830	16239
SSE	0	190	285	2664	1587	20992	25724
S	3	343	331	164	340	3864	5045
SSW	12	611	308	513	268	1848	3560
SW	69	181	204	311	300	1783	2848
WSW	46	179	533	458	1596	1899	4711
W	35	118	1754	1515	1054	2239	6715
WNW	40	320	2992	11076	3545	9791	27764
NW	20	288	1872	6667	1309	4004	14160
NNW	35	711	1727	1237	1304	6555	11569
Total	477	5,507	12,254	31,695	17,816	88,605	156,354

Source: ER-OL.

*To convert miles to km, multiply by 1.609.

In the ER-OL, the applicant provided population forecasts for 1983, 1990, 2000, 2010, and 2020. The applicant's projections, made in the mid-1970s, were overestimates, as the area has not experienced--nor is it likely to experience--the growth anticipated. Table 4.14 presents the staff's population projections for the year 2000 covering the area within 80 km (50 miles) of the plant. These forecasts are based on the Bureau of Economic Analysis population growth factors developed for NRC.

The transient population in the area around the site is associated with recreational, medical, educational, and industrial facilities. The Countryside Swim Club, Inc., within 2 km (1.3 miles) of the station, has an average daily attendance of 400 in season, with a daily maximum of 800. There are also boating and fishing on the Schuylkill River near the station, in which the large majority of participants are local residents. The applicant estimated that 1980 fishing

Table 4.13 1980 population distribution 0-50 miles from the site*

	Distance (mi)					
Sector	0-10	10-20	20-30	30-40	40-50	0-50
N	5,942	13,852	77,389	55,404	32,179	184,766
NNE	4,488	9,806	171,735	160,172	43,361	389,562
NE	4,630	27,015	20,825	32,741	41,920	127,131
ENE	6,016	48,565	44,094	19,228	37,624	155,527
E	6,368	66,210	130,398	172,614	325,744	701,327
ESE	10,575	121,142	738,105	582,275	120,212	1,572,309
SE	16,239	102,458	1,003,160	472,868	186,551	1,781,276
SSE	25,724	36,023	241,282	29,470	24,913	357,412
S	5,045	69,479	63,329	283,473	31,447	452,773
SSW	3,560	34,331	24,753	52,895	63,731	179,270
SW	2,848	18,936	32,093	18,112	17,387	89,376
WSW	4,711	9,607	24,384	93,101	102,841	234,644
W	6,715	4,671	23,397	50,215	68,920	153,918
WNW	27,764	91,986	89,366	25,195	38,855	273,166
NW	14,160	9,579	30,671	16,258	61,960	132,628
NNW	11,569	9,304	18,362	7,801	31,862	78,898
Total	156,354	672,964	2,733,336	2,071,822	1,229,507	6,863,983

Source: NRC Staff.

*To convert miles to km, multiply by 1.609.

within 5 km (3.1 miles) of the site totaled 8800 angler hours from May through September. Boating within 16.1 km (10 miles) is estimated to average 1100 boaters per year, mostly below Vincent Dam, 5.3 km (3.3 miles) below the site (ER-OL, response to NRC question 310.11).

Nearby medical facilities include the 275-bed Pottstown Memorial Center 2.9 km (1.8 miles) from the site. The Phoenixville Hospital (139 beds) and Eagleville Hospital and Rehabilitation Center (126 beds) are about 12.5 km (7.8 miles) and 14.4 km (9 miles) from the station. A state mental institution, Pennhurst Center, houses 1000 residents and is 4 km (2.5 miles) southwest of the site. There are nine nursing homes within 16.1 km (10 miles) of the station, the closest of which is in Pottstown, about 6.4 km (4 miles) away. The largest in the area is the 600-bed Montgomery County Geriatric and Rehabilitation Center in Royersford, 9.6 km (6 miles) from the plant.

Table 4.14 Year 2000 population distribution 0-50 miles from the site

	Distance (mi)*					
Sector	0-10	10-20	20-30	30-40	40-50	0-50
N	6,028	14,051	78,501	56,200	32,641	187,421
NNE	4,554	9,947	174,201	162,472	43,984	395,158
NE	4,698	27,403	21,124	37,148	47,562	137,935
ENE	6,102	49,262	44,728	21,816	42,688	164,596
E	6,460	67,161	132,263	175,093	369,589	750,566
ESE	10,726	122,881	748,705	660,649	136,393	1,679,354
SE	16,472	103,929	1,017,565	536,516	211,661	1,886,143
SSE	26,093	36,541	244,747	33,437	28,266	369,084
S	5,117	70,477	64,238	342,073	37,948	519,853
SSW	3,611	34,824	25,108	53,655	70,111	187,309
SW	2,889	19,208	32,554	18,372	17,637	90,660
WSW	4,780	9,745	24,734	94,438	104,318	238,015
W	6,812	4,738	23,733	50,936	69,910	156,129
WNW	28,166	93,307	90,650	25,557	39,413	277,093
NW	14,363	9,717	31,112	16,491	62,850	134,533
NNW	11,736	9,437	18,625	7,913	32,320	80,031
Total	158,607	682,628	2,772,588	2,292,766	1,347,291	7,253,880

*To convert miles to km, multiply by 1.609.

There are three school districts within 8 km (5 miles) of Limerick: the Owen J. Roberts School District (3600 students), the Pottstown School District (3200), and the Spring-Ford Area School District (3400). The Graterford Prison is about 13.3 km (8.3 miles) from the Limerick station and houses 1800 inmates. There are more than 11,000 persons employed within 8 km (5 miles) of Limerick, just about half of whom work for the six largest employers in the area. The nearest large firm is Hooker Chemical Co. PVC Division, which has 750 employees and is 2.4 km (1.5 miles) west-northwest of the station.

Presently the area within 8 km (5 miles) of Limerick is mostly open space and agricultural, but in the ER-OL (Table 2.1-19) the applicant predicts that by the year 2000, residential use will be the largest use of land. The FES-CP projected the expansion of residential land use in the area would occur as a result of the expected completion of the Schuylkill Expressway extension. However, the expansion did not occur, and the staff does not expect it to occur. There are two reasons for this: the expressway extension is still incomplete and sewage treatment facilities in the Limerick area are being utilized at capacity, with no immediate expansion foreseen.

4.3.7 Historic and Archeologic Sites

The FES-CP (Section 2.3) describes historic and archeologic sites. New information developed since the issuance of the FES-CP consists of additional archeological surveys reported or undertaken and the addition of properties to the National Register of Historic Places. Appendix F contains a listing of properties listed or eligible for listing on the National Register within 15 km of the site or within 2 km of the transmission routes. Buchart-Horn conducted an archeological survey on the site, the results of which were published in the ER-CP Supplement 1, in August 1972. The transmission line corridors were archeologically surveyed by John Milner Associates of West Chester, Pennsylvania. The Point Pleasant pumping station is under construction in the proposed Point Pleasant Village Historic District, which has been declared eligible for listing in the National Register. The pumping station site is in the general area of a prehistoric Indian settlement and is crossed by the Delaware Division of the Pennsylvania Canal, which is listed in the National Register of Historic Landmarks.

4.4 References

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5 ENVIRONMENTAL CONSEQUENCES AND MITIGATING ACTIONS

5.1 Résumé

This section evaluates changes in predicted environmental impacts since the FES-CP was issued in November 1973. Section 5.3.2 describes the changes in predicted impacts resulting from the volumes and concentrations of waste in the station effluents as a result of finalization of plant design and updated environmental data. Other hydrologic impacts are discussed in Section 5.3.3. Section 5.5 addresses terrestrial and aquatic impacts of operation, including the impacts of the Limerick transmission system and emergency spray pond. Section 5.8 provides the changes in the socioeconomic impacts.

Information in Section 5.9 on radiological impacts has been revised to reflect knowledge gained since the FES-CP was issued. The staffs evaluation of the Limerick plant-specific Probabilistic Risk Analysis (LGS-PRA) of severe accidents is presented in Section 5.9.4. Information on the environmental effects of the uranium fuel cycle, decommissioning, noise, and operational monitoring programs is provided in Sections 5.10, 5.11, 5.12, and 5.14.

5.2 Land Use

5.2.1 Plant Site

The staff evaluated the impacts of station operation on land use in the FES-CP (Section 5.1). The staff has re-assessed the impacts of plant operation and concludes that land use in the immediate site vicinity will not be changed as a result of plant operation. Effluents from the heat dissipation system (cooling tower drift and blowdown) are not expected to result in impacts that would cause changes in agricultural, residential, industrial, or recreational land uses in the site vicinity.

5.2.2 Transmission Lines

The impacts of transmission line operation on human and terrestrial ecosystems are discussed in Section 5.5. Land use along transmission lines is not expected to change as a result of transmission line operation except in three townships and one borough in Chester County where easements for hiking and biking trails have been agreed upon (see Section 4.2.2). Areas used for agriculture under and along the transmission lines are not expected to be impacted. The only areas precluded from agricultural use will be under the tower bases. Land use impacts are not anticipated along portions of the transmission system using existing transmission and transportation rights of way (see Section 4.2.6).

5.3 Water

5.3.1 Water Use

In Section 5.2 of the FES-CP, the NRC staff concluded that no significant impact on present or projected water use is expected as a result of water withdrawals by the Limerick station.

In regard to the Delaware River and Perkiomen Creek, the NRC staff still supports that conclusion, based on the Delaware River Basin Commission (DRBC) findings in the DRBC Final Environmental Assessment for the Neshaminy Water Supply System (DRBC, 1980). Since the Final Environmental Impact Statement (FEIS) for the "Point Pleasant Diversion Plan, Bucks and Montgomery Counties" was prepared by the DRBC in February 1973 (DRBC, 1980), the anticipated maximum withdrawal of Delaware River water has been reduced from 570 ml/day (150 mgd) to 361 ml/day (95 mgd). This maximum withdrawal of 361 ml/day (95 mgd) is approximately 5% of the minimum maintained river flow at Trenton of 7372 ml/day (1939 mgd), (3000 m^3/s). The maximum amount to be withdrawn for Limerick, 174.8 ml/day (46 mgd), is less than 2-1/2% of the minimum flow to be maintained at Trenton. Should river flows drop below 7372 ml/day at Trenton, withdrawals for Limerick will not be permitted without compensating releases from an upstream utility-owned reservoir. The DRBC concluded that water quality effects resulting from a reduction of the total amount of flow in the Delaware River available to dilute wastes as a result of withdrawals from the Point Pleasant Diversion would be negligible.

The 1980 DRBC environmental assessment states that there have been only minor changes in flows and channel alignments in Perkiomen Creek since publication of the FEIS in 1973 (and since publication of the NRC staff's FES-CP). The stream channel would be subject to much greater flow rates, depths, and velocities by natural flood flows than by proposed pumpages from the Delaware River. The DRBC also states that the proposed schedule of minimum flows (27 ft^3/s* during naturally low flow periods and 10 ft^3/s for the remainder of the year) would be a considerable improvement over existing conditions because the resulting minimum stream flow would be a greater fraction of the average stream flow and would occur during the winter. Also, water can only be withdrawn from Perkiomen Creek alone (without pumping from the Delaware) when flows at the Graterford gage are greater then 180 ft^3/s (for one unit) and 210 ft^3/s (for two units). A flow-duration table in the ER-OL for the period of record 1915-1980 shows that the median flow of Perkiomen Creek is 170 ft^3/s. Hence, water will be removed from the Perkiomen Creek watershed without replacement only during high flows. Thus, downstream effects are expected to be negligible.

The estimates of average and maximum rates of water withdrawal from the Schuylkill River and blowdown discharge to the river have not changed significantly since the FES-CP was prepared. The DRBC restrictions on pumping from the Schuylkill River also have not changed since the CP stage. The NRC staff concludes that use of the Schuylkill River by the Limerick station, under the conditions imposed by the DRBC, will not adversely affect present and projected uses of the river.

5.3.2 Water Quality

5.3.2.1 General

As stipulated by the NRC staff on October 19, 1982, the water quality considerations associated with discharges from the Bradshaw Reservoir are discussed below.

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*To change to m^3/s, multiply by 0.0283.

Water quality impacts in the vicinity of Bradshaw Reservoir, in the East Branch of Perkiomen Creek, in the Main Stem of Perkiomen Creek, and in the Schuylkill River may result from the creation of the Bradshaw Reservoir, the introduction of Delaware River waters into the Perkiomen Creek watershed, or the discharge of physical and chemical pollutants to the Schuylkill River during Limerick operation. The potential for impacts to receiving water quality was assessed during the construction permit review (FES-CP Sections 5.2 and 5.4 and the NRC ASLB Initial Decision of June 14, 1974). There have been changes in the volumes and concentrations of waste in the station effluents as a result of finalization of plant design and updated environmental data (see Sections 4.2.3, 4.2.6, and 4.3.2). The resulting changes in potential water quality impacts are discussed below.

5.3.2.2 Thermal Impacts of Blowdown Discharge on the Schuylkill River

The applicant has made several modifications to the design of the blowdown discharge system since the issuance of the FES-CP. These changes and the corresponding design parameters that were evaluated in the FES-CP are given in Section 4.2.4.

Because the blowdown discharge system has been redesigned, the applicant has re-evaluated the thermal plume predictions to ensure that the system will result in downstream river temperatures that are in compliance with the thermal limitations set by the DRBC in its Water Use Approval D-69-210CP (final).

The applicant has provided a thermal analysis revised from that presented at the CP stage. The revised analysis considers the final design of the Limerick blowdown diffuser, its location at the tip of Limerick Island, revised blowdown estimates, and updated Schuylkill River flow/temperature data. The analysis in the FES-CP considered anticipated winter and summer discharge conditions and assumed mixing of the blowdown with one-half of the available Schuylkill River flow at the site.

The revised analysis presented by the applicant used the predictive technique of Jirka and Halemean (1973), which does not account for surface heat loss or interfacial mixing (conductive heat loss across plume boundaries) in its predictions, but is based on heat loss through dilution with ambient river water. The analysis considered annual average, monthly average, and extreme combinations of Schuylkill River flow rate, Limerick blowdown (i.e., diffuser) flow rate, and river/blowdown temperature difference. The extreme condition considered the 7Q10 river flow rate and October Limerick blowdown and river temperatures. Using blowdown temperatures expected to be exceeded 50%, 5%, and 1% of the time, the applicant's model simulated the expected temperature rise 15.2 m (50 feet) downstream of the diffuser after the Limerick blowdown had mixed with one-third of the river flow at the site. The results of the simulations are given in ER-OL Table 5.1-1. For the blowdown temperatures expected to be exceeded 1% of the time, the largest increase in temperature expected 15.2 m (50 feet) downstream of the diffuser is predicted to be less than that predicted in the FES-CP, assuming mixing with only one-third of the river. These predictions are summarized in Table 5.1. The extreme case analysis using the 7Q10 and October 1% exceedance blowdown temperature indicates an in-river temperature rise 15.2 m (50 feet) downstream of the diffuser of 2.9°C (5.3°F). This value is comparable to the result of the NRC staff's worst case analysis given in the FES-CP (2.8°C, 5°F).

Table 5.1 Thermal analysis summary

Condition	Schuylkill River flow rate at diffuser, cms*	Temperature difference, blowdown vs. river, °C	Downstream temperature rise, °C
FES-CP			
Winter	6.16	13.7	1.17
Summer	3.22	2.8	0.556
ER-OL**			
Winter	20.94	19.46	0.8
Summer	10.8	13.34	0.89
Average	17.8	17.8	0.72

*FES-CP values represent one-half of river flow at the site passing over the diffuser; ER-OL values represent one-third of river flow at the site passing over the diffuser.

**Values shown for temperature differences are based on Limerick blowdown temperatures expected to be exceeded 1% of the time.

The results of the revised analysis indicate that, based on dilution with the assumed one-third of the river flow passing over the diffuser, complete mixing is accomplished within a short distance of the diffuser. The river is relatively shallow at and immediately below the discharge so that rapid mixing would be expected. The predicted temperature rise values are well below the DRBC-specified allowable surface temperature excess (2.8°C, 5°F) for all but the severe case. The Limerick discharge is expected to be in compliance with the applicable limitations because (1) the river channel widens downstream of the discharge, the additional flow from the river channel on the other side of Limerick Island is available for mixing immediately downstream of the discharge, and (2) the allowable excess surface temperature zone (46 m by 1067 m, or 150 feet by 3500 feet) is large compared to the area predicted to be needed for reduction of the excess surface temperature to below the 2.8°C (5°F)-allowable maximum.

5.3.2.3 Nonthermal Water Quality Impacts

<u>Point Pleasant Diversion: Delaware River and Bradshaw Reservoir</u>

The potential for adverse impact to the quality of surface water and groundwater in the Delaware River and in the vicinity of the proposed Bradshaw Reservoir has been assessed by the Commonwealth of Pennsylvania (Penna, 1982). This assessment considered impacts resulting from withdrawal of water from the river at Point Pleasant and the possible introduction of toxic substances into the proposed Bradshaw Reservoir and subsequently into the Perkiomen Creek watershed. The assessment concluded generally that the withdrawal will not result in adverse impacts to the water quality of the Delaware River downstream of Point Pleasant. Specifically, the assessment found (1) the operation of the Diversion will not compound existing water quality problems in the Delaware and Raritan

Canal (which withdraws water from the river at a point about 1600 m (1 mile) downstream of the Point Pleasant Diversion); (2) there will be no significant effect on concentrations of dissolved oxygen, trace organic substances, and suspended solids in the upper estuary, even during low flow and summertime flow conditions; (3) there will be no significant adverse effect on the assimilative capacity of the river and estuary; and (4) there will be no alteration to the concentration of trihalomethanes in the river as a result of the operation of the diversion (these concentrations have been reported to be below the level of detection in the City of Trenton's raw water supply).

The DRBC assessment (DRBC, 1980) notes that although the operation of the diversion will result in less flow below Point Pleasant being available to dilute substances introduced to the river below the diversion, the concentration of organic substances delivered to Point Pleasant from upstream drainage will not be affected by the diversion, because they would be removed proportionately with flow. Additionally, the assessment states that changes in water quality downstream of the diversion are not expected to be measurable as a result of its operation.

Based on a review of the Pennsylvania and DRBC assessments and on a review of the DRBC Level B Study of the Delaware River, the NRC staff concurs with the above assessments of the likely impacts to Delaware River water quality as a result of operation of the Point Pleasant Diversion.

With regard to the proposed Bradshaw Reservoir, the DRBC examined the potential for eutrophication in the reservoir (DRBC, 1980). The DRBC study concluded that although a eutrophication potential could be demonstrated, the short retention time of 3 days or less and the small reservoir size would not indicate a strong potential. The assessment concluded that these same factors would preclude the buildup of concentrations of algae and that the reservoir may in fact operate as a phosphorus sink, because of settling of particulates during retention. The Pennsylvania assessment of the water quality aspects of Bradshaw Reservoir concurs with the DRBC assessment (Penna, 1980).

The NRC staff has examined the quality of the water to be delivered to Bradshaw Reservoir via the Point Pleasant Diversion. Summaries of the available data on Delaware River water quality are in Section 4.3.2. With regard to the applicable general criteria of the DRBC and Pennsylvania and based on a review of the data collected by the applicant and others, the NRC staff concludes that the water quality of the Delaware River in the vicinity of the Point Pleasant Diversion is good and that the observed concentrations of toxics and detrimental substances are very low. The NRC staff concurs with the water quality characterizations of this reach of the river as presented by the DRBC and the Pennsylvania DER in their impact assessments of the Point Pleasant Diversion. The NRC staff notes that this water, which will be delivered to Bradshaw Reservoir, has been characterized by the Pennsylvania DER as being of satisfactory quality to be used for water supply.

The NRC staff has considered the potential for groundwater contamination that may result from seepage of water and toxics from Bradshaw Reservoir. Under the requirements of the Safe Drinking Water Act, the EPA has established National Interim Primary Drinking Water Regulations (40 CFR 141) and National Secondary Drinking Water Regulations (40 CFR 143). Although these regulations apply specifically to waters that have been processed in and delivered to a customer from a public water system and not raw, untreated waters like those to be transported to the proposed Bradshaw Reservoir, they do contain maximum contaminant levels (MCLs) for several impurities of concern in potable water supplies. The staff is aware that there are several individual drinking water wells in the vicinity of the proposed Bradshaw Reservoir location (response to staff question E240.24). Even though there is no statutory requirement for water in these wells to meet the criteria established under the Safe Drinking Water Act, in order to take a conservative approach, the staff compared the quality of the Delaware River water to the MCLs established under the Act.

A review of the data with respect to the MCLs established pursuant to the Safe Drinking Water Act indicates that six different constituents have been measured at least once at concentrations in excess of the MCLs. These are pH, cadmium, chromium, iron, manganese, and coliform bacteria. The MCL for pH, cadmium, and chromium have been exceeded infrequently. For example, records for 1975-1982 show that cadmium MCLs were exceeded only in 1976, and only one chromium value in excess of the MCL was recorded. The average values for these constituents have not been found to be in excess of the corresponding MCL. For the remaining constituents, the average values at both the proposed intake location and the sampling location immediately upstream in the Delaware River have been found to exceed the corresponding MCL as shown in Table 5.2 below. These measurements do not represent violations, because the provisions of the Act do not apply to the waters of the Delaware River that would be withdrawn at Point Pleasant nor to the Bradshaw Reservoir waters, both of which are untreated supply waters.

Iron and manganese at concentrations typically encountered in surface waters are not harmful to human health. Control of the concentrations of these minerals in domestic and potable waters is desirable because they have such adverse aesthetic effects as coloring the water, staining laundry, and imparting objectionable tastes to beverages.

Table 5.2 Average values of water constituents in the Delaware River, mg/l

	Range of mean values		Range of max values		MCL
	Intake	Upstream	Intake	Upstream	
Total Iron	0.36	0.41-0.48	2.06	2.97-3.00	0.30
Manganese	0.07-0.08	0.06-0.09	0.37-0.40	0.48	0.05
Coliform bacteria**	ND	6771	ND	154,000	1

*Each sample for iron and manganese consists of three replicates.
**Values shown are number of bacteria per 100 ml.

ND = No Data

Iron and manganese can be readily controlled to acceptable levels for domestic and potable water use during normal treatment of surface water supplies (1) through such processes as water softening, aeration, filtration, pH adjustment, and sedimentation, and (2) as a byproduct of normally applied disinfectants (e.g., chlorine). In groundwater supplies, these impurities can be controlled to acceptable levels through the use of water softening treatment systems that are available for individual supply systems (treatment systems for individual dwellings).

The proposed Bradshaw Reservoir will have an impervious liner installed that is designed to greatly reduce any water and waterborne contaminant seepage through the reservoir bottom (response to NRC staff request for information E291.24). The form of the iron and manganese (i.e., particulate or dissolved) in the reservoir water will also influence the amount of these constituents that may leave the reservoir with any seepage, because particulate forms could reasonably be expected to be upheld within the reservoir by the liner.

Bacteria levels are periodically very high when compared to the MCL of the Safe Drinking Water Act and the Pennsylvania DER and DRBC limitations. The movement of waterborne bacteria through the reservoir bottom will be hindered by the presence of the impervious liner and the buildup of any mat of organic materials, either on the reservoir bottom or within the soil. Other factors--such as soil and rock character, bacteria levels in the reservoir waters, growth media encountered in the soil, and the rate of groundwater movement--would affect the extent of any travel of bacterial contaminants in the vicinity of the proposed Bradshaw Reservoir.

In any event, the applicant's data (response to staff request for additional information E240.24) indicate that seepage is expected to flow to the northeast of the reservoir, where there are no existing wells (existing wells are located south of the reservoir) or recharge areas for existing wells.

Based on the above, the NRC staff concludes that the presence of iron, manganese, and coliform bacteria in Bradshaw Reservoir at concentrations similar to those measured in the Delaware River in the vicinity of Point Pleasant does not pose a significant threat to nearby existing groundwater wells.

The limited data on several pesticides controlled (in finished water) by the Safe Drinking Water Act are summarized in Section 4.3.2.2. The limit of detection of the measurements was below the MCLs for all of the parameters except endrin. All of the measurements indicated concentrations below the level of detection.

Concern over increasing contamination of groundwater by trichlorethylene (TCE) in the area near Point Pleasant has been noted in the DRBC and Pennsylvania DER assessments. Data on concentrations of TCE are summarized in Section 4.3.2.2. TCE appears on the EPA list of priority pollutants, but is not specifically controlled by the Safe Drinking Water Act. Under the Clean Water Act, the human health criterion for maximum protection from potential carcinogenic effects from exposure to TCE through ingestion of contaminated water and contaminated aquatic organisms is recommended to be zero. EPA has estimated incremental cancer risk increases of 10^{-5} and 10^{-7} for consumption concentrations over a human lifetime of 27 μg/l and 2.7 μg/l, respectively (45 FR 231, November 28, 1980).

Although no MCL has been established for TCE under the Safe Drinking Water Act, the EPA Office of Drinking Water has provided guidance to the Pennsylvania DER on levels of TCE for toxic effects excluding cancer (Schramm, 1979). These time-based concentration values provide a margin of safety from likely toxic effects that is estimated to result in negligible risks to the general human population and is based on 100% exposure to TCE from drinking water.

The 1-day suggested-no-adverse-response level (SNARL) is 2000 μg/l, and the chronic or long-term level is 75 μg/l (ibid.). The maximum recorded concentration of TCE in Delaware River water collected in the vicinity of Point Pleasant was 4 μg/l. On the bases of the available pesticide and TCE concentrations and detection frequency data and the above mentioned toxicity criteria, the NRC staff believes that the introduction of Delaware River water into Bradshaw Reservoir will not result in a significant threat of contamination of nearby drinking water wells with these substances.

Perkiomen Creek Watershed

Assessments of the likely impacts on existing water quality of the introduction of Delaware River water to the East Branch of Perkiomen Creek have been made by both the DRBC (DRBC, 1980) and the Pennsylvania DER (Penna, 1982). The DRBC assessment notes a similarity in the quality of the Delaware River waters in the vicinity of Point Pleasant and the quality of the head waters of the East Branch of Perkiomen Creek. The analysis of 1975-1978 water quality data indicates that there are somewhat higher ammonia concentrations in the diversion (i.e., Delaware River) water, but that any additional oxygen consumption associated with subsequent nitrification in the East Branch is not likely to cause problems (i.e., depressed dissolved oxygen) because of the low concentrations of phosphates involved. The assessment concludes that in addition to increasing the median flow rate of the East Branch, the quality and quantity of the introduced water, will improve degraded water quality conditions in the middle and lower reaches of the stream.

Phosphorus loadings of the East Branch from the diversion may increase in the headwaters, depending on the amount of settling of particulate phosphates in Bradshaw Reservoir. The assessment concludes, however, that even if no such reduction occurs, the water delivered by the diversion will act to reduce, by dilution, the phosphorus concentrations of the downstream East Branch of Perkiomen Creek. The Pennslyvania DER assessment of the compatability of the diverted water with that of the East Branch of Perkiomen Creek indicates that the waters are essentially equivalent in quality and that beneficial low or intermittent flow augmentation for the lower reaches of the creek is likely to result, improving water quality. As indicated in the previous section, because of the lack of evidence of significant levels of these substances in the Delaware River waters to be diverted, the Pennslyvania DER assessment concluded that the diversion will not result in the transfer of the toxic substances to the Perkiomen watershed.

The NRC staff has reviewed the water quality data collected by the applicant for the Delaware River and the East Branch and Main Stem of Perkiomen Creek. A comparison was made of selected Delaware River and East Branch headwaters quality data for the low flow period of the year (June through October, the period during which the diversion is most likely to be operating) through 1978. Calculated

95% confidence intervals of sample mean data show overlapping intervals for only two of eight parameters tested (biochemical oxygen demand and total dissolved solids) indicating comparability. The estimates of the interval boundaries encompassing the mean values indicated that the Delaware River waters were higher in concentration of ammonia and nitrate nitrogen, orthophosphate phosphorus, and total iron. The pH value of the river was also indicated to be higher than the creek headwaters. The calculations indicated that the East Branch headwaters were higher in sulfate concentration. These data are inconsistent with the DRBC and Pennsylvania DER assessments with regard to nitrate nitrogen, probably because of the different bases of comparison (the June to November period used by the NRC staff versus the entire year used by DRBC). The maximum recorded nitrate nitrogen values of the creek headwaters for all quarters and the median values for the December-February and March-May quarters are higher than the corresponding river values.

Ignoring any removal of nutrients in Bradshaw Reservoir, the comparison of water quality data through 1978 (the latest available from the East Branch of Perkiomen Creek) indicates that during the expected period of operation of the diversion, ammonia and nitrate nitrogen and orthophosphate levels in the East Branch headwaters are likely to increase. However, the downstream areas of the East Branch (represented by sampling locations E22880 and E2800) and the area of the Main Stem of Perkiomen Creek near the Limerick Graterford intake show higher median and maximum concentrations of these constituents, especially during the September-November quarters. Thus, the diversion could benefit these downstream areas by the addition of waters less heavily nutrient laden during the low flow periods of the year.

The indicated difference in pH between the diverted water and that of the East Branch headwaters during the low flow periods of the year do not exceed one unit and would not cause a violation of water quality standards for the creek. The indicated higher total iron concentration of the river water for the time period examined is not expected to be a problem in the East Branch because (1) the concentrations are within established water quality limits for the designated stream uses; (2) the river concentrations are, based on the calculated confidence limits, only about 25 to 30% higher than the headwater values; and (3) available data on the East Branch show a decrease in total iron concentrations in the downstream direction, indicating an existing removal mechanism or dilution effect.

Based on the NRC staff's review of the available water quality data of the applicant, the effects of the operation of the proposed Point Pleasant Diversion on the water quality of the East Branch and Main Stem of Perkiomen Creek is expected to be largely beneficial, as indicated in the DRBC and Pennsylvania DER environmental assessments.

Schuylkill River

Assessments of the likely impact of the operation of Limerick on the water quality of the Schuylkill River by the DRBC and the Pennsylvania DER since the issuance of the FES-CP have been limited to consideration of the concentration effect of the station's evaporative cooling system on chloride levels in the river. DER (Penna. 1982) concluded in its assessment that the low concentration factor of the closed cycle cooling system would not cause any violations of water quality standards, even during critical (i.e., low) flow conditions in the river. The applicant estimates that the maximum seasonal chloride concentrations in the station blowdown will exceed the DER maximum of 150 mg/l only during the June-July-August quarter. However, when this blowdown concentration of 151.2 mg/l is mixed with one-third of the Schuylkill River flow at the site, it would be reduced to about 40 mg/l, only slightly above the ambient river concentration. The applicant calculates that this would take place less than 91 m (300 feet) downstream of the station diffuser.

The applicant has estimated the seasonal range and median values of the major water quality constituents in the Limerick discharge on the basis of a simulation of station operation, on variations in source water quality over the simulation period, and on applicable DRBC constraints on source water withdrawal. The results of the simulation are in Table 4.3. The applicant compared the Limerick constituent discharge concentrations after they were mixed with one-third of the river flow and the corresponding constituent concentrations at the Schuylkill River discharge location for the seasonal range and median values (ER-OL Tables 5.3-1 through 5.3.1-4). The constituent extrema resulting from this comparison were compared with applicable Pennsylvania water quality criteria. The results of the comparison indicate that, for those constituents with numerical limitations, the Limerick blowdown concentrations would at some time exceed the criteria for 10 constituents (see Table 5.3). The results did not predict that the extrema and criteria would be exceeded simultaneously for all of these constituents. Of the 10 constituents, 5 extrema are predicted to exceed the criteria even after they mix with one-third of the river flow downstream of the diffuser. For these five (ammonia nitrogen, cadmium, iron, manganese, and mercury), all but one of the discharge extrema that exceed the criteria (i.e., all but manganese) correspond to the mixed intake extrema that exceed their respective criterion, indicating that the constituent concentrations of the source waters exceeded the criteria as well. For all of these constituents, the corresponding extrema concentrations in the Schuylkill River equal or exceed their respective criterion. With the exception of ammonia nitrogen, the constituent maxima predicted to exceed water quality criteria after mixing are those noted by the applicant to be conservative. That is, they are affected only by the concentrating effect of the Limerick evaporative cooling system and not by direct addition of chemicals during station water use or treatment. Ammonia nitrogen concentrations are affected as a result of the operation of the station cooling system (e.g., water temperature change, chemical oxidation) and water treatment (e.g., chlorination) and not by direct treatment with ammonia-containing chemicals. It is predicted that these constituent maxima will exceed the applicable criteria not only because of station operation, but also because of ambient water quality conditions both in the Limerick source waters and in the receiving water.

Nonnumerical water quality criteria are set for copper, nickel, and zinc. Comparisons of the extreme mixed discharge concentrations of these constituents with the limited median tolerance level bioassay data for species present at the site indicate that the concentrations would exceed those estimated to be safe (ER-OL Table 5.3-7), based on long-term exposure.

Comparing seasonal median mixed intake, Limerick blowdown, mixed discharge, and Schuylkill River ambient concentrations of major discharge constitutents, the number of constituents exceeding the applicable criteria is greatly reduced, as shown in Table 5.3. Of the four constituents whose predicted median discharge concentrations exceed the applicable Pennsylvania or U.S. EPA numerical criteria,

Table 5.3 Comparison of discharge, mixed river concentrations, and quality criteria for maximum discharge concentrations in excess of criteria

Parameter	Concentration, mg/l				
	Blowdown	Schuylkill River[1]	Mixed intake	Mixed river[2]	Criterion
Total dissolved solids	1136	546	334	460	750
Sulfate	616.7	211.9	163.1	216.1	250
Ammonia nitrogen	9.52	1.60	1.89	1.89	0.02
Nitrite and nitrate nitrogen	10.99	5.88	3.82	4.05	10.0
Cadmium	0.41	0.005	0.012	0.013	0.012
Chromium	0.054	0.036	0.016	0.043	0.10
Iron	46.1	9.313	13.56	14.761	1.5
Lead	0.377	0.130	0.111	0.348	0.05
Manganese	2.295	1.26	0.67	1.187	1.0
Mercury[3]	1.8	2.1	0.5	1.2	0.05

[1]Station S77140.
[2]Based on one-third of Schuylkill River flow at the site.
[3]Values given are μg/l.

Source: ER-OL Table 5.3-6

only those for ammonia nitrogen are expected to be above consistently the applicable standard (for every yearly quarter). Ambient median Schuylkill River values for ammonia nitrogen are also consistently above the criterion (as are the seasonal median mixed intake water concentrations), yielding mixed river concentrations downstream of the diffuser that are above the criterion as well. The mixed river concentrations (i.e., median blowdown concentration mixed with one-third of the median river flow rate for the season of interest) for the remaining constituents--total dissolved solids, sulfate, and manganese--are calculated to be below their respective water quality criterion limits.

For copper, nickel, and zinc, the seasonal median mixed river concentrations are essentially equal to ambient Schuylkill River concentrations. The calculated median copper and zinc concentrations are below the median tolerance limit after accounting for the appropriate application factor for some resident biota at the site and above it for others. The median calculated discharge concentration of nickel, 0.00 mg/l, is below the limit of detection and is therefore believed to be in compliance with the criteria.

The predicted mixed discharge constituent concentrations for the Schuylkill River 7-day 19-year low flow (7.1 m^3/s (250 ft^3/s)) and for the lowest observed river flow during the preoperational sampling program (12.2 m^3/s (435 ft^3/s))

indicate concentrations below those given in Table 5.4. Only ammonia nitrogen and mercury concentrations are predicted to be above their respective quality criteria. The ambient Schuylkill River concentrations for these two constituents at low flow conditions were also predicted to be above the criterion values. A comparison of the predictions for low flow concentration with the predictions based on maximum discharge concentrations taken from the simulation of actual Limerick operation and intake and receiving water quality indicates that constituent maxima occur at other than low flow conditions in the Schuylkill River.

Table 5.4 Comparison of discharge, mixed river concentrations, and quality criteria for median discharge concentrations in excess of criteria

	Concentration, mg/l				
Parameter	Blowdown[1]	Schuylkill River[2]	Mixed intake[3]	Mixed river[4]	Criterion[5]
Total dissolved	752	270	221	299	750
solids	758	272	223	296	750
Sulfate	281.5	66.8	66.8	75	250
Ammonia nitrogen	2.78	0.48	0.47	0.56	0.02
	2.14	0.25	0.22	0.30	0.02
	1.38	0.08	0.02	0.16	0.02
	1.63	0.19	0.07	0.26	0.02
Manganese	1.153	0.326	0.339	0.36	1.0

[1]From ER-OL Table 3.6-3. Multiple values represent different seasonal medians above the applicable water quality criterion.
[2]From ER-OL Table 2.4-12, Station S77660.
[3]From ER-OL Table 3.6-2.
[4]Based on mixing with one-third of applicable seasonal median flow, from ER-OL Table 2.4-12; diffuser flow, from ER-OL Table 5.1-1.
[5]From ER-OL Table 5.3-6.

The use of chlorine for biofouling control at Limerick will result in the discharge of chlorine-containing compounds in the cooling tower blowdown (see Section 4.2.6.2). The applicant plans to control the addition of chlorine to the cooling systems or alter the blowdown from the unit being chlorinated so that the total residual chlorine (TRC) (the sum of the free available chlorine and the combined available chlorine) concentration in the blowdown will not exceed 0.22 mg/l for two-unit operation. One-unit operation is expected to produce a TRC in the discharge of up to 0.43 mg/l during chlorination (response to NRC staff request for information E291.11). Assuming mixing with one-third of the Schuylkill River flow at the site and based on complete mixing within 91 m (300 feet) of the diffuser, as indicated for the thermal performance of the diffuser, this concentration would be expected to be reduced to less than 0.02 mg/l (a dilution factor of 15) by the time the effluent waters reach the downstream edge of the thermal mixing zone. The Water Quality Management Permit No. 4671202 issued by the Commonwealth of Pennsylvania (response to staff request for information E291.12) currently limits only the concentration of free available chlorine in the cooling tower blowdown of each unit, as measured in the station discharge. The stated limit of 0.25 mg/l allows levels of residual chlorine in the blowdown higher than those expected by the applicant during two-unit operation, but lower than those expected during one-unit operation. The applicant's planned two-unit maximum concentration is about the same as that reviewed by the NRC staff in the FES-CP, which was judged to be sufficiently low to avoid adverse impacts on the quality of the receiving water. Available data from operating power plants indicate that residual chlorine in cooling tower blowdown is comprised nearly exclusively of combined available chlorine.

The staff believes that the Industrial Waste Permit concentration level will be met during two-unit operation and that concentrations of free available chlorine are likely to be below detectable limits in the blowdown from the unit being chlorinated for the following reasons:

(1) Chlorine biocide addition at Limerick will be controlled by measurement of residual concentration in the cooling tower blowdown, with free available chlorine monitored at the condenser outlet waterbox.

(2) The chlorinated cooling water will be exposed to air, sunlight, and biological growths in the cooling towers.

(3) The chlorinated water will be sampled in the cooling tower basin before discharge (with provisions to terminate blowdown from the cooling tower being chlorinated until the residual chlorine concentration falls within the permitted limit).

The U.S. EPA New Source Performance Standards for Generating Units (40 CFR 423.15) prohibit the discharge of detectable residual chlorine from either Limerick unit for more than 2 hours in any 1 day, unless the applicant demonstrates that the units cannot operate within the restriction. The applicant's current plans call for chlorinating the condenser circulating cooling water system via intermittent 20-minute chlorine biocide additions for a total of 2 hours per day per unit. The releases from this system (blowdown and drift) are much less than the circulating water flow rate, and the system volume is large compared to the blowdown volume during the application period. A finite time beyond the termination of the addition of chlorine biocide is required for the contents of the system to change completely. Thus, assuming that a substance added to the system completely mixes with the contents of the system, this substance could be expected to be present--at a reduced concentration--in the blowdown and drift for periods beyond the time it is added to the system. The applicant's analysis is based on projected Limerick cooling water chemistry, biocide applications of 20-minute duration, and field studies on TRC concentration in an operating power plant. This analysis indicates that TRC concentration in the station discharge will be greater than 0.1 mg/l (the practicable field detection limit for residual chlorine) for 50 minutes during two-unit operation (one unit chlorinated) and for 77 minutes for one-unit operation (response to NRC staff request for information E291.11).

The applicant currently plans to chlorinate the condenser circulating waters of only one unit at a time. This operating scheme is consistent with the current restrictions in the recently promulgated U.S. EPA Final Effluent Limitations Guidelines, Pretreatment Standards and New Source Performance Standards for the Steam Electric Power Generating Point Source Category (U.S. EPA, 1982). Employment of the nonsimultaneous chlorination scheme provides for residual chlorine reduction in common discharges by dilution with the unchlorinated discharge water and by reaction with chlorine-demanding substances in the unchlorinated waters. Because residual chlorine is toxic to freshwater life and therefore is controlled by Pennsylvania under the Warm Water Fishes and Migratory Fishes Standards (Penna, 1979), these reduction mechanisms are important in attaining water quality sufficient to meet applicable standards within the mixing zone and in minimizing the volume of water in the vicinity of the discharge that could contain residual chlorine concentrations deleterious to aquatic life.

The regulations of the DRBC and the PDER permit the designation of mixing areas in receiving waters for pollutants other than heat. The determination of such areas, if any, is done on a case-by-case basis. For Limerick Generating Station, this determination will be made during development of the NPDES permit. Outside of this area, the cooling tower blowdown discharge shall not cause a violation of the water quality standards. According to these standards (ibid.), substances attributable to waste discharges are not to be present in amounts inimical or harmful to protected water uses or to human, animal, plant, or aquatic life. A water quality standard for TRC for the protection of freshwater organisms, other than salmonid fish, has been established by EPA (U.S. EPA, 1976) under the provisions of the Clean Water Act at 0.01 mg/l. This level was established on the basis of a review of toxicity studies conducted by EPA and others, and is applicable to a continuous exposure to residual chlorine. Other continuous-exposure, safe concentrations or chronic toxicity thresholds have been set by Brungs (1973) and Mattice and Zittel (1976) for freshwater organisms. The limitation recommended by both these studies is 0.003 mg/l. Exposure to residual chlorine at or below this level would not be expected to kill aquatic organisms. However, these criteria considered cold water organisms (i.e., salmonid) as well as warm water organisms, and may be unduly restrictive for the organisms in the Schuylkill River. For comparison, the EPA limitation for salmonid fish is 0.002 mg/l. Other studies by Dickson et al. (1974) and Brooks and Seegert (1978) examined the effects of intermittent exposures of warm water fishes to residual chlorine. These studies concluded that exposures to TRC not greater than 0.2 mg/l intermittently for a total of up to 2 hours per day would "probably be adequate to protect more resistant warm water fish such as the bluegill" (Dickson et al., 1974) and that intermittent exposures to combined available chlorine totaling 160 minutes would not kill the most sensitive of 10 warm water fishes tested at concentrations at or below 0.21 mg/l. The most sensitive species in the latter study was the emerald shiner. The other species tested were the common shiner, spotfin shiner, bluegill, carp, white sucker, channel catfish, white bass, sauger, and freshwater drum.

The most restrictive chlorine water quality criterion for a fresh warm water fishery is that in the EPA "Red Book" (U.S. EPA, 1976), 0.01 mg/l. As stated above, the applicant estimates that the proposed operation of Limerick will result in degradation of residual chlorine concentration to less than 0.02 mg/l during two-unit operation and about twice that during one-unit operation in an area well within the mixing zone established by the DRBC. These dilution estimates do not account for reaction of residual chlorine with reducing substances in the receiving water and account for mixing with only one-third of the available flow over the diffuser. Chemical reaction and additional mixing beyond the initial mixing area will reduce residual chlorine levels to those commensurate with the levels identified in the "Red Book."

The applicant estimates that the need to chlorinate the station cooling towers will arise infrequently (about four times per year per tower). The concentration of biocide in the cooling tower basin and in the discharge is estimated to be much higher at these times than during the normal condenser biofouling control applications. The applicant has stated that blowdown from the cooling towers would be suspended for the period during and after cooling tower biocide treatment when the free available chlorine concentration is greater than 0.5 mg/l. When monitoring indicates that the free available chlorine (FAC) concentration has fallen below this threshold, blowdown would be resumed. FAC concentrations of 0.25 mg/l (the maximum FAC concentration in the station discharge assuming treatment of one cooling tower and full diluting flow from the remaining untreated cooling tower) to 0.5 mg/l (the maximum FAC concentration that would exist in the undiluted blowdown) are known to be toxic to aquatic biota. The chlorinated discharge from a treated tower would also contain an at-present undeterminable amount of combined available chlorine, which also is toxic to aquatic biota, in addition to the FAC. The relatively large volume of water affected by these treatments and relatively long time that the waters containing high residual chlorine would be discharged following a cooling tower biocide treatment episode would combine, resulting in station discharges that could be toxic to or produce behavioral changes (e.g., avoidance reactions) in biota in the Schuylkill River in the vicinity of the station discharge. The Pennsylvania DER, as the NPDES permit issuing agency, has the authority to limit the maximum allowable concentration of residual chlorine in the station discharge during cooling tower chlorination. Actions to mitigate these potential impacts are available such as suspending cooling towner blowdown until residual chlorine concentration degrades to an acceptable level, monitoring TRC in the treated cooling tower basin, rather than FAC concentration alone, as a criterion governing discharge of these waters, and dechlorination, if necessary, to reduce residual biocide concentrations in the discharge below harmful levels (although this would increase the total dissolved solids in the discharge).

Chlorination of the plant cooling waters is likely to produce chlorinated compounds in the cooling tower blowdown in addition to the active chlorine residual, as discussed above. The 1974 EPA National Organic Reconnaissance Survey (NORS) showed that chlorination of natural surface waters supplying drinking water for 80 cities around the country resulted in the formation of chlorinated organic compounds, primarily trihalomethanes (THM). Of these, the predominant compound was chloroform, but bromodichloromethane, dibromochloromethane, and bromoform were included. In contrast, studies of 14 different water utilities and their raw water supplies by Arguello et al. (1970) indicate that THM are found at only low concentrations (0 to 15 μg/l), if at all, in nonchlorinated natural surface waters. The NORS indicates that total organic carbon in the raw water at the time of chlorination and the chlorine dosage are significant parameters governing THM formation. A study by Stevens et al. (1976) also showed that pH affects chloroform formation in chlorinated natural waters. The results indicate that the rate of formation of chloroform (the predominant THM found) increases with increasing pH.

A study by Young and Singer (1979) of raw water chlorination by a water utility and the effects of chlorination and THM formation in the finished water indicated that the presence of free chlorine residuals in concentrations greater than 0.4 mg/l appeared to enhance the THM formation. NRC staff experience indicates that typical target free available chlorine concentrations for biofouling control in power plant heat exchangers are 0.5 to 1.0 mg/l for the duration of the application period. The applicant's target for Limerick is 1.0 mg/l. Thus, the results of the Young and Singer study would tend to indicate that the proposal to chlorinate to 1.0 mg/l will be conducive to THM formation in the cooling water. The estimated total organic carbon concentrations in the Limerick intake waters indicate a range of from 0.0 mg/l to 24.1 mg/l, which encompasses the range of total organic carbon values in the water utility studies. Characteristics of the power plant system not present in the water utility systems that may serve to reduce the THM-forming potential of the cooling water are the short chlorine contact time and the possible THM removal by air stripping (i.e., volatilization loss of chloroform) during passage through the plant cooling tower, as observed by Jolley (1978). For chloroform, the loss was about 84% in that study.

Additional preliminary information is available from an NRC-sponsored study (Bean et al., 1981; Bean, 1982; Bean 1983) in the form of measures of THM concentrations in intake and chlorinated discharge samples collected from operating nuclear power plants. The plants sampled have closed cycle cooling systems, including both natural draft cooling towers and mechanical draft cooling towers. The cooling water systems of the plants were chlorinated to total residual chlorine levels of 1 to 5 mg/l. Dechlorination was practiced at one of the plants, and blowdown was held up in one mechanical draft cooling tower-equipped plant until the residual chlorine concentration fell below 0.05 mg/l. The results are shown in Table 5.5. The chlorinated discharge samples show chloroform concentrations typically below 1 μg/l, although one plant had a concentration of 2.4 mg/l. The chlorinated discharge samples had total THM concentrations as high as 3.64 mg/l, but half the samples measured were below 1 μg/l. Where measured, intake total organic carbon concentration was 12 to 15 mg/l, which is within the range of values predicted for the Limerick intake waters.

The U.S. EPA has published water quality criteria (U.S. EPA, 1980a, b, c) for chloroform and halomethanes that will, "when not exceeded, reasonably protect human health and aquatic life" (U.S. EPA, 1980a). The chloroform concentration at which only 50% of the test organisms survived for the exposure period, generally 96 days, for Daphnia magna is 28,900 μg/l, while that for Lepomis machrochirus (Bluegill) is 100,000 μg/l. For halomethanes, the LC50 for bluegill is stated to be 11,000 μg/l, based on brominated compounds. A no-adverse-effect threshold test was conducted for Daphnia magna, and the corresponding chloroform concentrations were found to be between 1,800 μg/l and 3,600 μg/l. With regard to human health effects, based only on consumption of contaminated aquatic organisms, the concentration that has been identified to result in not more than a 10^{-6} risk of incremental cancer over a lifetime is 15.7 μg/l chloroform or other trihalomethane; the corresponding concentration based on consumption of contaminated water as well as contaminated organisms is 0.19 μg/l.

Under the Safe Drinking Water Act National Primary Drinking Water Regulations, a maximum contaminant level (MCL) has been established for total THMs. This MCL is 100 μg/l and is applicable to the delivered water to customers of public water systems that serve 10,000 or more individuals and that add a disinfectant (oxidant) to their water during treatment.

Table 5.5 Triholomethane concentrations in unchlorinated intake and in chlorinated discharge cooling water at operating nuclear power plants (preliminary information), μg/l

Parameter	Intake	Discharge
Chloroform	ND-0.40	0.24-2.4
Bromodichloromethane	ND-0.03	ND-0.78
Dibromochloromethane	ND-0.04	ND-0.80
Bromoform	ND	ND-0.30
Total triholomethane	ND-0.40	0.25-3.64

Sources: Bean et al., 1981; Bean 1982 and 1983.
ND - Not Detected

The exact THM concentrations in the Limerick discharge cannot be predicted at this time. The results to date of the NRC research program on THM concentrations in the discharges of operating closed cycle nuclear power plants indicate concentrations well below those identified as having adverse effects on aquatic biota and well below the MCL for total THMs (note, however, that the MCL is not applicable to the Limerick discharge or to the concentrations in the Schuylkill River that may come to exist therein as a result of Limerick operation). The intermittent chlorination of Limerick cooling waters and the treatment of Schuylkill River water by water utilities prior to consumption serve to mitigate consumer exposure to THMs from Limerick operation and the presently estimated adverse human health risks therefrom.

5.3.2.4 Sanitary Waste Impacts

The Limerick operational phase sanitary waste system will utilize a readily available, conventional, secondary level of treatment employing extended aeration. The system has sufficient capacity when it is operating in the extended aeration mode to treat the wastes (at 107.5 l/cap/day (28.5 gal/cap/day)) of about 350 persons. During refueling, the system will be operated in a contact stabilization mode to treat the wastes of about 1100 persons. Effluent limitations for this treatment plant are in Pennsylvania DER Bureau of Water Quality Management Sewage Permit No. 4672437 and U.S. EPA NPDES Permit No. PA 0024414, and are given in ER-OL Section 5.4. The effluent limitations set by the permits are readily attainable by this treatment technology, if the system is properly controlled by a qualified operator. Small sewage treatment plants operated in the extended aeration mode often suffer periodic upsets because of hydraulic overloading and sudden increases in influent organic loading. These upsets would lead to degraded effluent quality. Even for periods of less than design treatment performance, detectable adverse impacts on receiving water quality are not likely because treated wastes from this system are directed to the cooling tower blowdown line at a rate that is small compared to the blowdown flow rate (i.e., less than 1% of the blowdown flow rate). The NRC staff concurs with the applicant's assessment that the treated sanitary wastes will have a negligible effect on the combined Limerick discharge water quality.

5.3.3 Other Hydrologic Impacts

5.3.3.1 Water Level Changes in the Delaware River Caused by Pumping for Limerick

The water level at the Point Pleasant intake on the Delaware River is primarily controlled by the Lumberville Wing Dam, approximately 1.6 km (1 mile) downstream of the site. The applicant prepared a stage rating curve for the site based on water level measurements at the intake location and U.S. Geologic Survey (USGS) discharge measurements at Trenton, adjusted for drainage area difference and instream storage. The NRC staff reviewed the applicant's rating curve and made independent calculations of water level versus discharge for weir flow over Lumberville Wing Dam. Based on these calculations, the NRC staff considers the applicant's curve accurate for flows down to 3000 ft^3/s. The NRC staff considers the worst drawdown case to be maximum pumping at the intake when the flow in the river is 3000 ft^3/s.

The change in water level at Point Pleasant as a result of pumping 95 mgd (147 ft^3/s) from the river when the natural flow is 3000 ft^3/s would be less than 2.5 cm (1 inch). The change in water level as a result of pumping for Limerick alone would be about one-half of this. When the flow in the river is below 3000 ft^3/s at Trenton, the applicant must provide compensating upstream releases for withdrawals. For this situation, the net result in water level change as a result of Limerick pumping would be zero. The staff concludes that water level change at Point Pleasant as a result of pumping for Limerick is insignificant.

5.3.3.2 Wedgewire Screen Bypass Velocities at Point Pleasant

To determine the velocity past the intake screens during low flow periods in the Delaware River, the applicant measured velocity across the river during two low flow periods. The NRC staff reviewed these measurements, along with bathymetric profiles and other data, and concluded that for flows of 3000 ft^3/s the bypass velocity in the river along the center line of the screens would be at least 0.77 fps,* with the most likely velocity about 1.0 fps. For flows of 2500 ft^3/s, which is the lowest predicted flow at the intake under extreme drought conditions, the bypass velocity is estimated to be at least 0.64 fps, with the most likely value about 0.8 fps. The average intake velocity of the screens for the maximum pumping rate of 95 mgd is 0.35 fps.

5.3.3.3 Sedimentation and Erosion in Perkiomen Creek

Water pumped from the Delaware River will enter the East Branch of Perkiomen Creek through a 42-inch**-diameter pipe and an energy-dissipating structure. Between the energy dissipator and the creek will be a 70-foot-long riprap-lined channel. Perkiomen Creek will also be riprapped for about 100 feet upstream

*To change feet to meters, multiply by 0.3048.
**To change inches to mm, multiply by 25.40.

and 60 feet downstream of its confluence with the channel from the pipeline. In addition to placing riprap, the applicant will inspect the creek periodically after pumping begins, even though erosion is not expected. If significant erosion should be found, the applicant will provide appropriate erosion control measures, in consultation with the DRBC.

During the winter, flows will be sufficiently high in the Schuylkill River for plant consumptive use withdrawals under the DRBC restrictions. Diversions to Perkiomen Creek for pumping to Limerick will not normally begin until after the annual spring high flow period. The natural spring flows will flush the streambed of loose deposits. Because the maximum diversion rate is small compared to the spring flows, the start of pumping is not expected to cause additional sediment to be washed downstream. There is not expected to be a significant addition of sediment to the stream from the Delaware River water because the Bradshaw Reservoir will tend to act as settling basin for the relatively small amount of suspended sediment that may be withdrawn by the Delaware River intake screens.

5.3.3.4 Seepage from Bradshaw Reservoir

The Bradshaw Reservoir will serve as the point of discharge for water pumped through the combined transmission main; it will be located on the drainage divide between North Branch of Neshaminy Creek and the South Branch of Geddes Run. The reservoir will be formed by earthen dikes varying in height from 5 to 23 feet above the existing land surface. The dikes will form a square reservoir about 900 feet on a side, with a water surface area of about 7.6 hectare. The maximum operating capacity of the reservoir will be 70 million gallons at el 435.0 feet msl. The permeability of the proposed 2 foot-thick clay liner is estimated to be no more than 5 x 10^{-6} m^3/s. Based on this permeability, the reservoir area, and the water depth, the applicant calculated a maximum seepage rate of 0.5 mgd. The NRC staff has reviewed the applicant's calculation and considers it to be conservative. The applicant's calculation did not take credit for the low permeability rock formations underlying the reservoir. The presence of these formations will reduce the calculated seepage considerably. Thus the NRC staff concludes that seepage from the Bradshaw Reservoir will add very little recharge to the groundwater aquifer beneath the reservoir site. In addition, water wells near the reservoir are upgrade of the groundwater flow and will not be affected by seepage from the reservoir.

Although the design of the Bradshaw Reservoir has been reviewed and approved by the Pennsylvania Department of Environmental Resources (Penna, 1982) there was concern expressed by an intervenor (Delaware Unlimited, Inc.) during the October 1982 hearings before the ASLB on SCWS contentions about the potential for groundwater contamination if one of the dikes surrounding the reservoir should fail. During an inspection of the proposed reservoir site, the NRC staff noted that the area surrounding the reservoir is well drained with no large areas available for ponding. Because of the low permeability of the surrounding soils, any infiltration during the short period of overland flow following a dike failure would be minimal. The NRC staff concludes that a dike failure at Bradshaw Reservoir would not result in significant recharge to the underlying aquifers or contamination of groundwater sources of drinking water.

Also, nearby houses are located near the upper end of the reservoir where the dikes are only 4 to 5 feet above the surrounding ground level. Hence any flooding as a result of the unlikely event of a dike failure would not result in damage to nearby homes.

5.3.3.5 Floodplain Effects of the Project on the Schuylkill River, Delaware River, and Perkiomen Creek

The 100-year flood discharge on the Schuylkill River adjacent to the plant site, as determined from a study performed for the Federal Insurance Administration (FIA), is 79,000 ft^3/s (FEMA, 1980). The pre-construction river flood elevation for that flow adjacent to the plant is 129 feet msl. The major post-project change to the Schuylkill River floodplain is the presence of the pumphouse structure. Its effect on 100-year flood elevation was determined to be minimal. Therefore, no change in the flood characteristics of the Schuylkill River are expected as a result of construction of the plant. The floor of the pumphouse at elevation 137 feet msl is about 8 feet above the 100-year flood level.

The 100-year flood discharge on Perkiomen Creek adjacent to the Perkiomen Creek pumping station, determined from a study performed for FIA, is 42,300 ft^3/s (FEMA, 1981). The pre-construction creek flood level for that flow was determined to be el 125.7 feet msl adjacent to the pumping station. The post-construction 100-year flood level was determined to be el 125.8 feet msl. Because of this minimal (0.1-foot) change in flood level, no significant additional upstream flooding impacts on Perkiomen Creek are expected as a result of the presence of the pumping station. The floor of the pumping station is at el 130.0 feet msl; hence it will not be flooded during the 100-year flood on Perkiomen Creek.

The 100-year flood discharge on the Delaware River adjacent to the Point Pleasant pumping station, determined from a study performed for the FIA, is 284,000 ft^3/s (FEMA, 1979). The pre-project flood level for this discharge at the pumping station is el 103 feet msl. The pumping structure, which has a ground level floor elevation of 106.7 feet msl, will not encroach on the 100-year floodplain. There will be some encroachment, however, from a small filled area to the rear of the station where the transformer substation and a parking lot will be built. The placement of this fill will result in the loss of only an insignificant fraction of the cross-section conveyance that is available under present pre-construction conditions. Therefore, no significant rise in the 100-year flood level upstream is expected as a result of construction of the pumping station.

The pre-construction and post-construction 100-year floodplains for the Schuylkill River, Perkiomen Creek, and Delaware River pumping stations are shown in Figures 5.1, 5.2, and 5.3.

5.4 Air Quality

5.4.1 Fog and Ice

The evaluation of the atmospheric impacts as a result of the operation of natural draft cooling towers at Limerick is unchanged from that presented in the FES-CP.

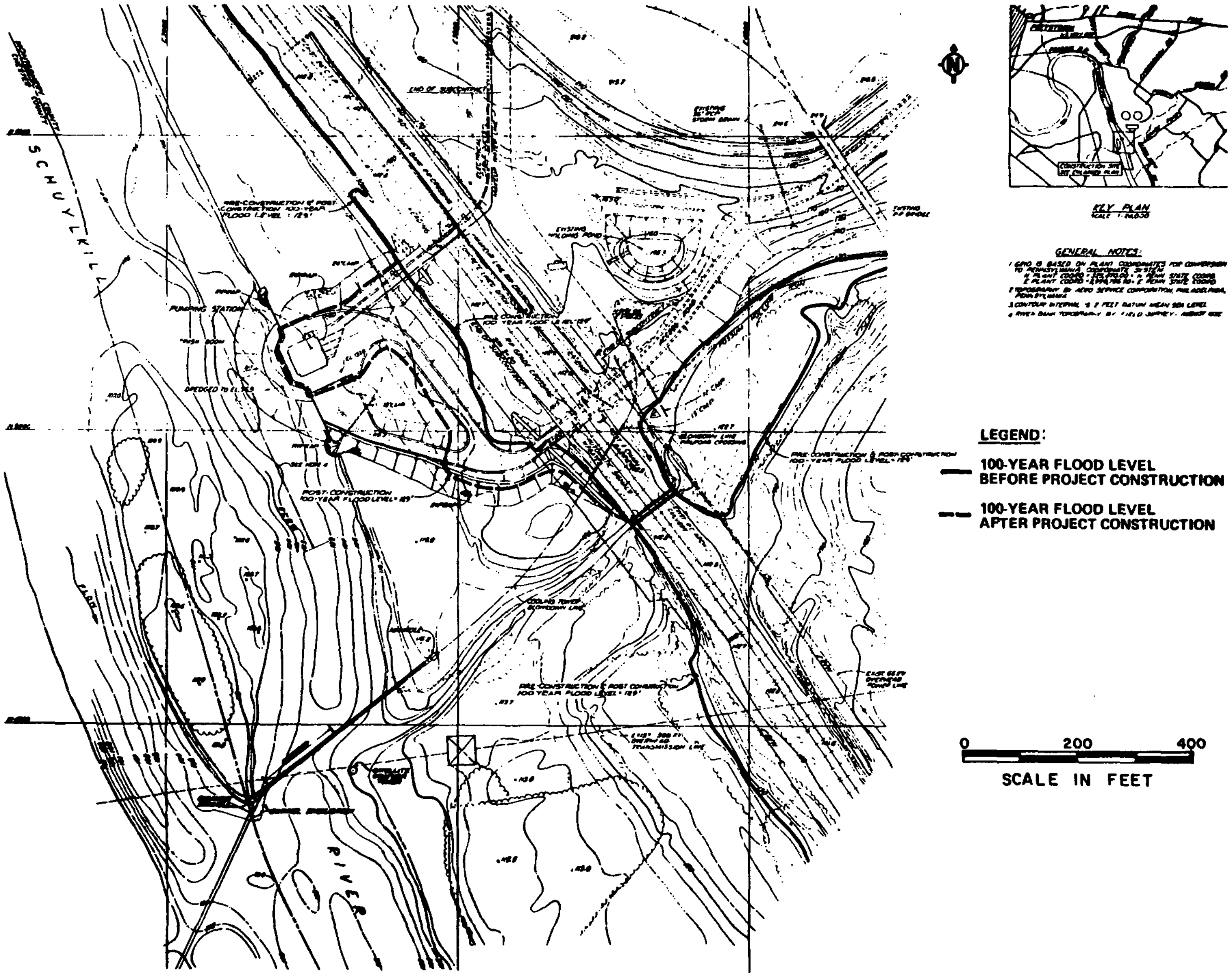


Figure 5.1 100-year floodplain near Schuylkill pumping station

Source: ER-OL Figure 2.4-7a, March 1982

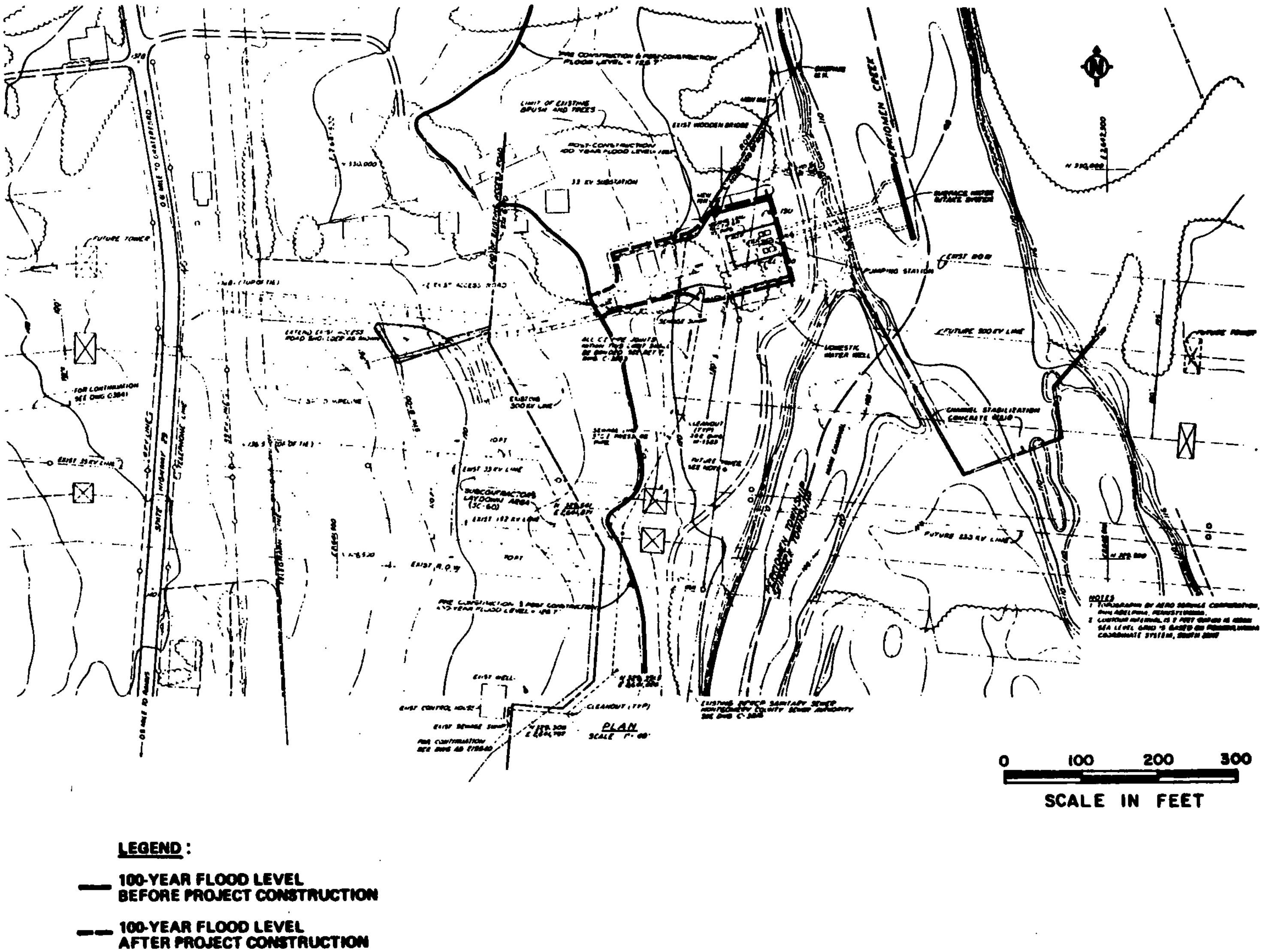
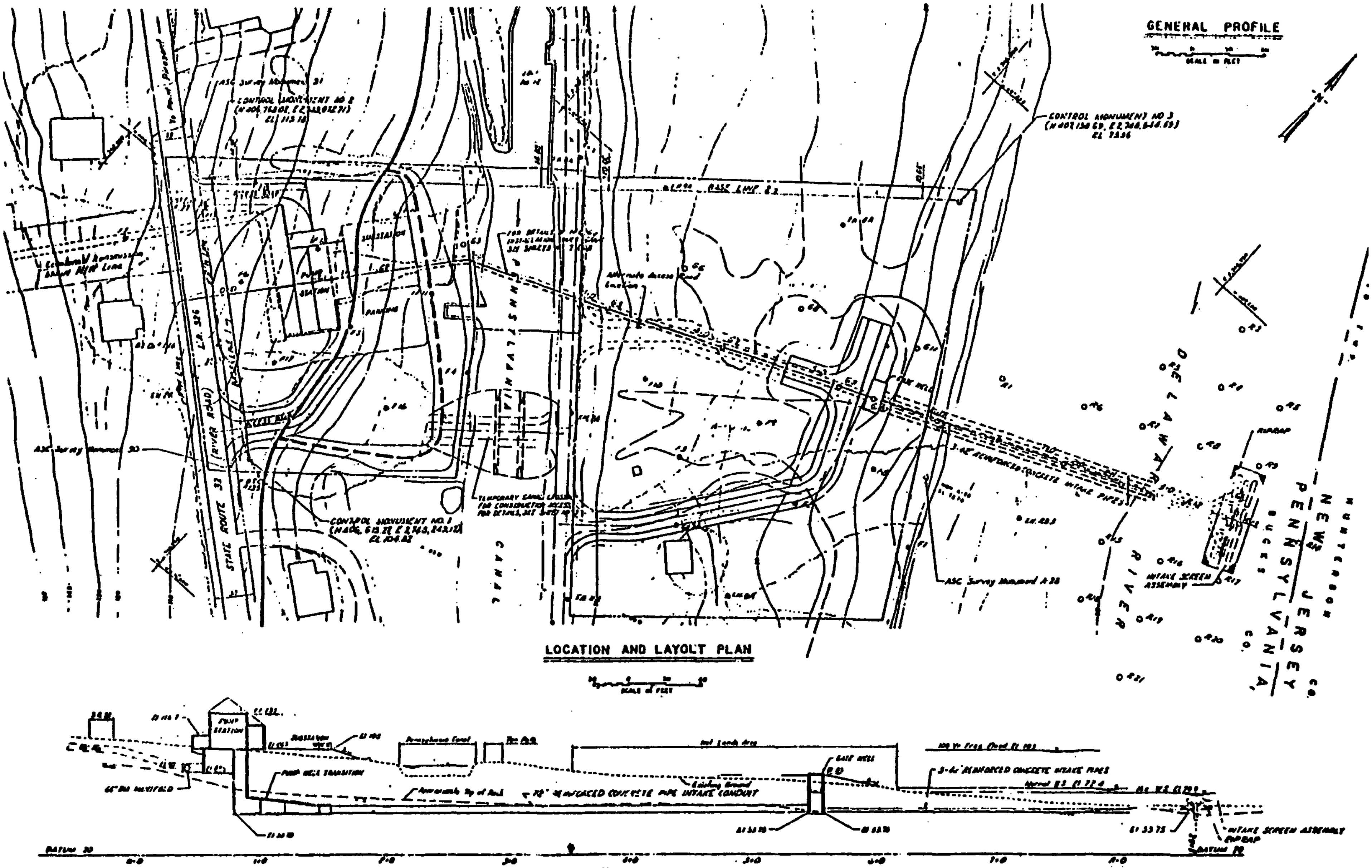


Figure 5.2 100-year floodplain near Perkiomen pumping station

Source: ER-OL Figure 2.4-7b, Revision 3, March 1982



EXPLANATION

——— 100 Year flood level before project construction

– – – 100 Year flood level after project construction

Figure 5.3 100-year floodplain near Point Pleasant pumping station

Source: ER-OL Figure 2.4-7c, Revision 3, March 1983

5.4.2 Other Emissions

Air quality impacts from nonradioactive atmospheric pollutants (particulates, sulfur dioxide, and nitrogen oxides) were not addressed in the FES-CP. Three auxiliary boilers, any two of which may be in use at any one time, will emit particulates, sulfur dioxide, carbon monoxide, hydrocarbons, and nitrogen oxides when in operation. The boilers proposed for use at Limerick are identical to those in use at Peach Bottom, and the applicant has used actual fuel consumption at Peach Bottom to estimate emissions from the boilers at Limerick. Considering use of No. 2 fuel oil with a sulfur limit of 0.3% by weight, the applicant has estimated that emissions from the auxiliary boilers will be less than EPA de minimis levels for particulates, sulfur dioxide, carbon monoxide, and nitrogen oxides. The applicant has not estimated hydrocarbon emissions, nor has the applicant considered the emissions from the emergency diesel generators. However, based on similar emission estimates from other nuclear plants, the NRC staff concludes that operation of the auxiliary boilers and emergency diesel generators at Limerick should not have a significant impact on air quality in the vicinity of the plant.

5.5 Terrestrial and Aquatic Resources

5.5.1 Terrestrial Resource Impacts

5.5.1.1 Cooling Tower Salt Drift

The applicant has calculated salt drift deposition rates in the 16 22.5-degree compass sectors surrounding the two natural draft cooling towers (ER-OL Table 5.1-16). The maximum drift deposition was calculated to be 7.7 kg/ha/yr (6.8 lb/ac/yr) at a location approximately 0.8 km (0.5 mile) east-southeast of the towers. Salt drift deposition isopleths are given in ER-OL Figure E290.16, Revision 15. The maximum monthly salt deposition is expected during August, also in the east-southeast sector, at a rate of 1.2 kg/ha/mo (1.06 lbs/ac/mo). The NRC staff has reviewed the applicant's methodology for derivation of the salt drift deposition values and concludes they are reasonable estimates.

The applicant's drift deposition estimates are well below the levels of 10-20 kg/ha/mo (54-109 lbs/ac/mo) believed to cause leaf damage to sensitive plant species (NUREG-0555). The NRC staff does not believe that deposited salts will accumulate in the soil to levels toxic to vegetation during the operating life of the Limerick station. The soils of the immediate site vicinity are classified as silt loams having moderate to rapid permeability (USDA, 1967). Good soil permeability coupled with an annual precipitation of 45 inches (FES-CP Section 2.6) should result in salts leaching from the surface layers (i.e., 8-12 inches of topsoil). The NRC staff concludes that cooling tower drift will not adversely affect native vegetation or agricultural crops in the immediate vicinity of the Limerick station.

5.5.1.2 Transmission System

5.5.1.2.1 Operation

The staff has reviewed the environmental impacts that could be associated with the operation of the Limerick transmission system. The potential sources of impact are (1) ozone production, (2) induced electrical currents, (3) electric fields, and (4) transmission line right-of-way maintenance.

Ozone is produced along operating extra high voltage (EHV) transmission lines by corona discharge. Various parameters associated with conductor geometry (e.g., bundle configuration, conductor size, abrasions on conductor surface, foreign particles on conductors, ground wire configuration), operating voltage, and adverse weather conditions influence the level of corona discharge. Increments to ground level ozone concentrations from corona discharge are greatest when the atmosphere is stable, when winds are parallel to the conductors and at velocities less than 1 m/s (2.2 mph), and during rain, snow, or fog (U.S. Department of Energy, 1979). Expert testimony at hearings before the New York Public Service Commission on the potential environmental effects of 765-kV overhead ac transmission lines concluded that, under the worst weather conditions, 5 to 9.2 ppb ozone will be added to ground level atmosphere directly under the lines (ibid.). The results of six field studies measuring ozone levels along transmission lines ranging from 138-kV to 765-kV showed that corona discharge did not add significantly to ground level atmospheric concentrations (III, 1979).

Based on the review of these and other documents on biological impacts from ozone exposure and on a review of the applicant's plan to use conductor bundle configurations that minimize corona discharge (ER-OL Section 3.9.3), the NRC staff concludes that no adverse environmental impacts will occur from operation of the 230-kV and 500-kV transmission line system. Further, ozone generated by the lines will not result in violations of the National Primary Ambient Air Quality Standards for photochemical oxidants of "80 ppb maximum 1 hour, not to be exceeded once per year" (Section 109(b)(1) of the Act, 43 USC 1857C-4(b)(1)). Many rural and urban areas were in violation of the 80 ppb ozone standard as early as 1974 and 1975 (IIT, 1979). The small amounts of ozone generated by the Limerick transmission lines will likely be within the normal range of ambient concentrations.

The applicant's transmission system design incorporates minimum conductor-to-ground clearance of 7.9 m (25 feet) and meets or exceeds requirements of the National Electric Safety Code (NESC) Section 23 (ER-OL Section 3.9.1.3). The NRC staff believes that vertical conductor clearances of 7.9 m (25 feet) or more will not result in induced currents in metal objects under or along the lines because of electrostatic effects. The 5-milliampere level used as a shock criterion in the NESC Code will not be exceeded. The applicant also has committed to grounding conducting objects such as metal fences in the vicinity of transmission line right of way (response to NRC request for information E290.2). Fences will be grounded either by connection to 3-m (10-foot) metal rods driven into the ground or by connection directly to the system ground if they are near a transmission tower or substation. The NRC staff concludes that these mitigative actions will reduce any potential shock hazards to levels that will not result in any adverse human health effects.

The NRC staff believes that induced shock will not adversely impact biota along the Limerick transmission corridors. Raptors perched on towers are unlikely to build up an induced voltage because they are grounded through the tower grounding system. Conductor spacing in the 230-kV and 500-kV lines is sufficiently great to preclude short-circuiting by outspread wings of raptors in flight.

The NRC staff has reviewed the potential for avian collisions with the Limerick transmission lines. Of particular interest are stream and river crossings and marsh habitat, which are areas where birds may be abundant during migration and the breeding season. Although considerable attention has been given to transmission line impacts on birds in flight (Anderson, 1978; Avery, 1978; and Avery, et al., 1980), the NRC staff is unaware of any evidence documenting the biological significance of line collisions on avian populations. Several potential mitigative measures have been suggested by Avery (1978), but there is a lack of documentation for the effectiveness of most of these.

The NRC staff observed two areas of concern during its site visit. The first area involved three crossings of the Schuylkill River along the Cromby-to-Plymouth Meeting 230-kV line (see Figure 4.4). The second area is where the Limerick-to-Whitpain 500-kV and Cromby-to-North Wales 230-kV lines share a common corridor across Perkiomen Creek. The NRC staff does not believe that either area will serve as a major migration route, and it believes that clearance will be sufficient to minimize impact to birds in flight. Further, the staff has consulted with wildlife biologists from Montgomery County and the State of Pennsylvania. They have advised that significant bird impaction events have not occurred at transmission lines crossing the Schuylkill River and Perkiomen Creek and they do not expect a problem with bird impactions on these lines in the future.

Energized transmission lines produce electric fields in the region of space surrounding the line conductors. Such fields can transfer electrical energy to conductive bodies--including biota--that lie within these fields. This transfer of electrical energy can occur directly from the transmission line to the individual without contact, producing a current within or on the surface of the organism. For the Limerick transmission system, the applicant predicts maximum electric field strengths will occur along the 500-kV line from Limerick to the Whitpain substation approaching a value of 8.2 kV/m (ER-OL Figure 3.9.3). (The intensity of the electric fields at ground level is expressed in units of kilovolts per meter or kV/m.) This segment of corridor will contain two 500-kV lines and a 230-kV line in a 158-m (520-foot) wide corridor. The applicant predicts that electric field strengths along other Limerick transmission line segments will vary from 1 to 5 kV/m. Typically, electric field strengths will be highest under 500-kV lines within a band approximately 6 to 18 m (20 to 60 feet) from the centerline. Field strengths decline moderately toward the centerline and drop quickly to approximately 2 to 3 kV/m at the edge of the right of way.

Some research studies have observed physiological and/or behavioral effects suggesting possible adverse health effects in people from exposure to electric fields (MPSC, 1979; DOE, 1979; and DOE, 1982). The NRC staff believes, however, that research studies to date have been carried out using electric field strengths and exposure times on organisms that are greater than would be expected for people residing or working along transmission lines. Also, many of the studies have been challenged on the basis of poor experimental design and inadequate statistical treatment of results (DOE, 1979).

The NRC staff has reviewed a vast amount of data on electric field effects of EHV transmission lines and concludes that there is little evidence to indicate that people are adversely affected by electric fields at power line frequencies. The electric fields of 2 to 3 kV/m produced along the edges of the rights of way of the Limerick 230-kV and 500-kV lines are not expected to adversely affect humans. The NRC staff believes that humans would not be chronically exposed to electric field gradients in excess of the maximum edge of right-of-way value of 3 kV/m because people are not permitted to live on the right of way and, therefore, would not receive a long-term constant exposure.

Results of research studies on electric field effects on growth and development of plants and animals indicate that neither adverse injuries or abnormalities were apparent from exposure to a 50-kV/m field (Bankoski, et al., 1976). Minor physical damage to corn, bluegrass, and alfalfa leaf tips occurred from exposures to field strengths of 25 kV/m and above. The same series of studies investigating electric field effects on small animals indicated no apparent adverse abnormalities in behavior or external appearance from exposures to electric fields of 50 kV/m.

Based on its analysis of electric field effects on biota, the NRC staff does not believe that changes in the applicant's proposed transmission line design are warranted.

5.5.1.2.2 Transmission Line Corridor Maintenance

The applicant plans to implement a vegetation control program that will include selective clearing through mowing, trimming, and the use of herbicides. Vegetation--such as low growing trees and shrubs (e.g., dogwood, sumac, mountain ash, and various evergreens)--that attains a height of 5 m (15 feet) or less will not be cleared or require maintenance trimming (ER-OL Section 4.2.1). The selective clearing or trimming of vegetation may impact some nesting song birds. The impacts should be minimal, however, and should not pose a threat to existing populations because vegetation trimming will occur intermittently through the years and will take place during only a few days of the nesting season.

The applicant has provided a list of 10 herbicides that may be used singly or in combination to control vegetation along transmission line rights of way associated with the Limerick station (ER-OL Section 4.2.1). These herbicides have been approved by the Environmental Protection Agency. The NRC staff finds these chemicals acceptable when they are applied properly. The impacts to non-target biota from herbicide application will be minimal because broadcast spraying will not be used. The NRC staff will require that the applicant maintain a record of herbicide application that will include the herbicide used, concentrations and amounts applied, and the location and time of application.

5.5.1.3 Emergency Spray Pond

The NRC staff has analyzed the impacts to terrestrial wildlife from operation of the emergency spray pond. The pond covers 3.9 ha (9.6 acres), has a depth of 2.7 m (9 feet), and is lined with bentonite. The applicant plans to test pond operation 2 to 3 hours a month. Algal growth will be controlled by slug applications of hypochlorite averaging 227 kg (500 lbs) per application (ER-OL Section 3.6.2), so that free available chlorine concentration does not exceed 0.5 mg/l.

The NRC staff believes that waterfowl species such as mallards and black ducks may visit the spray pond during the summer months. Additional waterfowl species are likely to use the pond as a resting area during the spring and fall migration periods. The addition of hypochlorite should eliminate algae, a food source for surface-feeding waterfowl. The bentonite liner in the pond should preclude the establishment of rooted emergent and submergent aquatic plants that comprise important waterfowl habitat. Monthly testing of the pond during the winter months will reduce ice formation and serve to attract local waterfowl.

The NRC staff does not believe, however, that waterfowl will stay on the pond because of a lack of food and cover in the pond and a lack of food in the immediate pond vicinity. With respect to water quality in the pond, the applicant indicates (ER-OL Section 3.6.2) that chemical concentrations will be approximately 1.4 times the concentration of Schuylkill River water. No standards have been established for water consumed by wildlife. When the NRC staff compared the Limerick makeup water concentrated 1.4 times with recommended limits for livestock drinking water (Lewis et al., 1978) it was apparent that concentrations in the pond will be considerably below these standards. The NRC staff concludes that routine testing of the emergency spray pond will not adversely impact terrestrial wildlife.

5.5.1.4 Pipeline Corridor Maintenance

The NRC staff has evaluated the operational impacts of the makeup water pipeline from the Point Pleasant Diversion on the Delaware River to the East Branch of Perkiomen Creek. Detailed environmental assessments of constructing and operating the line are provided in two documents provided by Pennsylvania state agencies (Neshaminy Water Resources Authority (1979), and the Pennsylvania Department of Environmental Resources (Penna, 1982)).

For the most part, once the pipeline is assembled and buried, disturbed areas will be graded and seeded with grasses and impacts to biota will be minimal during the life of Limerick. It is the NRC staff's conclusion that the conditioned approvals obtained from the Delaware River Basin Commission and the conditioned permits obtained from the Pennsylvania Department of Environmental Resources and the Army Corps of Engineers by the Neshaminy Water Resources Authority to construct the various components of the makeup water pipeline from the Point Plesant Pump Station on the Delaware River to the Bradshaw Reservoir and by the applicant to construct the pipeline from Bradshaw Reservoir to the East Branch of Perkiomen Creek will adequately ensure that the maintenance of the pipeline corridor will be performed in such a manner that it will not cause a detrimental environmental impact (DRBC 1971, 1973, 1975, 1980, 1981; Penna 1982 and Manai 1981).

5.5.2 Aquatic Resources Impacts

5.5.2.1 Schuylkill River

The potential impacts to the aquatic resources of the Schuylkill River from operation of the Limerick cooling system have been reviewed by the NRC staff. These reviews are summarized briefly in Section 4.3.4.2 of this statement.

Intake Impacts

The ASLB Initial Decision (LBP-74-44) authorizing CP issuance found the impacts of operation of Limerick acceptable, while recognizing that one of the adverse effects that cannot be avoided is "the loss of some fishes" (page 1140). Specifically, the ASLB found that one of the environmental costs was "potentially adverse effects on biota near proposed water intake on Schuylkill River" P(1141).

Section 4.3.4.2.4 above states that the most abundant species in the vicinity of the Limerick intake were shiners, sunfishes, white sucker, brown bullhead, and goldfish. The smaller species (shiners, sunfish) and young of larger species (sucker, bullhead, goldfish) will be most susceptible to impingement on the traveling screens. Bullhead and sucker have been common in impingement samples at the Cromby generating station, suggesting their potential susceptibility at Limerick also. Fishes that are weakened by disease, wounds, or parasites could be especially susceptible to impingement. The abundance of several species apparently peaks during fall and winter and in areas of macrophyte abundance. Schuylkill River water use by Limerick will be highest from about October/November through April, which encompasses the aggregation period of the fishes. Macrophytes are common to abundant in the vicinity of the intake; thus impingement of fishes can be expected. Peaks in numbers of impinged fishes could occur during fall and winter when water use is greatest, fishes are congregating in the macrophyte areas near the intake, and young fishes are present and perhaps migrating.

Fish impingement will occur at Limerick; however, the impacts should be minimal to the river population for the following reasons: (1) the most abundant species near Limerick also are abundant throughout the river study area; (2) habitat-forming macrophytes are extensive in the river and are not unique to the site; (3) passage in the river for fish movements exists in the west river channel that is removed from the sphere of influence of the intake; and (4) approach velocities will be lowest during the higher river flows of winter and early spring. Compared with the design reviewed at the CP stage (Section 4.2.4), the present use of one intake (rather than two) and a reduced approach velocity of 0.5 to 0.6 fps (compared with 0.75 fps) will reduce the comparative potential for impingement impact.

The ASLB-CP findings essentially are unchanged: there are potentially adverse effects on biota near the intake, but acceptable overall impacts. The NRC staff finds, however, that macrophyte beds in the river near the intake and a high incidence of disease among several species could result in higher levels of impingement for some species than is suggested in the FES-CP.

Entrainment of larval fishes also will occur at the Schuylkill River intake. The species that are likely to be the most susceptible are goldfish, minnows, carp, and sunfishes (Section 4.3.4.2.4). Spawning probably occurs in the vicinity of the intake, perhaps in and around macrophyte beds. The presence of the macrophyte beds limits the effect of the intake and provides a secure habitat for the larvae. It is anticipated that impacts to the river fish population will be minimal for the following reasons: (1) the larval species abundant near Limerick also were abundant throughout the river study area; (2) although spawning does appear to occur near Limerick, the area does not appear to be unique in this respect; (3) few fish eggs were collected near Limerick (most river fishes deposit demersal eggs that are not susceptible to entrainment); (4) the peak larval abundance occurred during June and July, a period when 70% of the Limerick water needs will be supplied from diversion water from the Delaware River and Perkiomen Creek.

Discharge Impacts

The ASLB Initial Decision (LBP-74-44) found that "the thermal effect of the discharged water will be insignificant" to the biota of the river and that "the heat dissipation system is acceptable from an economic and environmental standpoint" (page 1138).

In the ER-OL (Section 5.1.3.1.2), the applicant states, and the NRC staff agrees, that effluent temperatures near the diffuser occasionally will exceed the upper avoidance levels of some fish species, and that some displacement of fishes from the area could occur. During average river flow conditions, the plume may extend across nearly the entire east channel, with one-half to one-third of the river flow passing over the diffuser (see Section 4.2.4). Upriver movement of fishes during some months, therefore, might be restricted to the west channel. Should this occur, fish might be "detoured" or "shunted" around Limerick Island and the intake structure, thus reducing the potential for impingement. Attraction of fishes to the plume also could occur; however, the rapid discharge velocity of 9 to 11 fps should preclude most fishes from entering or residing for extended periods in the warmer discharge temperature area. Cold shock resulting from shutdown during the winter should not create significant impact, because simultaneous shutdown of both units will occur infrequently. A one-unit shutdown will result in thermal effluent still being discharged from the second unit via the combined two-unit diffuser.

Avoidance and attraction of fishes likely will occur as a result of thermal discharges. Fishes that might be most susceptible to stress or mortality could be those that are already stressed by disease conditions. Mortalities, however, are expected to be minimal. The ASLB finding of acceptable impacts is still valid.

Summary

The AEC staff findings of acceptable overall impact reported in the FES-CP, affirmed by the ASLB at the CP stage, remain valid. Impacts on a river-wide or pool-wide basis should not be significant, and the Commonwealth's designated water uses will not be significantly affected (Section 4.3.2.5). Because angler use in the vicinity of Limerick essentially is nonexistent, fishing activity will not be disrupted there. It appears, however, that localized effects to biota could result from impingement and thermal effluents on a seasonal basis. Even though these stresses will be minor, they will be an addition to an already stressed system and degraded environment.

5.5.2.2 Delaware River

The FES-CP did not directly address impacts to the Delaware River as a result of water withdrawals at Point Pleasant. The FES-CP relied on the 1973 environmental impact statement (EIS) prepared by the Delaware River Basin Commission (DRBC, 1973). The AEC staff stated that it agreed with the general conclusions reached by the DRBC in that statement. In summary, the DRBC found that the Point Pleasant Diversion would not be detrimental to the Delaware River if the intake structure were designed to prevent entrainment of fish. At that time, the diversion was designed as a shoreline intake canal with traveling screens (see Section 4.2.4). Subsequent to that AEC review, the NRC ASLB issued a Partial Initial Decision on Supplementary Cooling System Contentions on March 8, 1983. That decision and review examined the present wedgewire screen proposal in light of potential impacts to shortnose sturgeon and American shad, and to recreational fishing in the Delaware River. The ASLB found (Finding 12) that the passive wedgewire screen intake utilizes state-of-the-art technology, and that the presently proposed intake location and design are preferable to the original proposal of a shoreline intake with vertical traveling screens. The ASLB concluded that the intake would not impact any life stages of the two species reviewed and that recreational fishing for American shad would not be affected adversely.

The present wedgewire screen intake design represents a change that significantly reduces the potential for impacts to river biota. Impingement of adult and juvenile fishes will be virtually eliminated, and entrainment will be significantly reduced. Most river fishes (except the anadromous shad, herring, and alewife) deposit eggs demersally on the river bottom, and many (such as the sunfishes) do so near shore. The present design, therefore, reduces the likelihood that most species of hatched larvae will encounter the intake (as compared with a shoreline structure). Intake canals with protective devices such as weirs or jetties can serve to attract fish or divert them into the canal, as do trap nets and pound nets with their leaders extending from shore. This design change, therefore, represents a significant improvement in environmental protection for river biota. The present design will not entirely "prevent" entrainment (as per the AEC concurrence with the 1973 DRBC requirement), but it will reduce the entrainment potential significantly. The FES-CP reliance on the DRBC conclusion of no detrimental impact is substantiated and remains valid.

An examination of the biotic resource information about the Delaware River near Point Pleasant (see Section 4.3.4.2.1) that has become available since the FES-CP was issued suggests that the area is becoming more important for use by migrating fishes and that a variety of resident fishes also use the area throughout their life cycles. A low-impact intake design, therefore, appears to be appropriate. The recent data also describe a diverse biotic assemblage with a relatively low abundance of pollution-tolerant forms. This suggests that the area is not severely pollution stressed and is capable of sustaining any minor effects imposed by the present intake design. The data also indicate that the area has excellent potential for improvement as a fishery/aquatic resource as a result of pollution abatement programs and fishery revitalization programs (as for American shad). A low-impact intake design that will not interfere with the goals of such programs also is appropriate.

5.5.2.3 East Branch of Perkiomen Creek

The FES-CP did not directly address impacts to the East Branch of Perkiomen Creek resulting from diversion water inflow. The FES-CP relied on the 1973 EIS prepared by the DRBC. The AEC staff stated that it agreed with the general conclusions reached by the DRBC. In summary, those conclusions were

(1) The upper quarter of the East Branch will experience some adverse impact in the form of bank erosion and sedimentation after the initial period of inflow; the impact period was anticipated to be brief; and the impact was considered to be very slight (page 33 of the DRBC EIS).

(2) From Sellersville upstream to the discharge (inflow) point, some aquatic life may be altered because of the increased flow, but generally an enhancement of aquatic life is anticipated (EIS page 35).

(3) The diversion will increase the fishery potential and enhance long-term productivity because of the continuous minimum flow (EIS pages 35 and 44).

Diversion of water from the Delaware River into the East Branch will affect the biotic resources as a result of: (1) water volume and flow increase, especially during seasons of normally low flow; (2) reduction in flow variability, producing a more stable physical environment; (3) alteration of pool and quiet water areas in the upper section of the creek during low flow seasons; (4) improvement in water quality in the middle and lower sections of the creek as a result of dilution with diversion water; (5) reduction in the habitat diversity or heterogeneity of the creek as a result of the absence of low flow in the upper section; and (6) possible introduction of Delaware River species into the creek.

The applicant has provided a thorough discussion of impacts of diversion on the East Branch in ER-OL Section 5.1.3.3, including a discussion of indicator species. The NRC staff agrees with those findings.

The upper section of the East Branch will be affected most by diversion water inflow, primarily during the low flow season when its normal condition is a series of isolated pools with little flow between them (Section 4.3.4.2.2). This headwater section contributes significantly to the habitat diversity or heterogeneity of the creek and contains a biotic assemblage that is different from those of the middle and lower sections. This increased abundance probably is the result of crowding of fish in isolated pools during the spawning season when flow is low and and intermittent (Table 4.7). Alteration of this upper section assemblage will result in a reduction of biotic diversity of the East Branch system. Representative biota that will serve as indicators of such change are shown in Tables 4.6 and 4.7. Based on these tables, examples of expected changes could be as follows:

(1) Macroinvertebrates (Table 4.6)

- decrease in abundance of pollution tolerant species, especially in middle creek section as a result of dilution of low quality water with higher quality Delaware River water; effects perhaps most noticeable during summer-fall low flow period; species affected: oligochaete worms, leeches, snails, and clams.

- increase in abundance and distribution within the creek of species with low pollution tolerance as a result of dilution-related water quality improvements in middle and lower sections; species affected: caddisflies, micro-caddisflies, and some midge species.

- decrease in abundance of headwater species that are tolerant of intermittent flow, such as stoneflies and perhaps crayfish of Cambarus sp.

(2) Fishes (Table 4.7)

- redistribution upstream of species from the lower section as a result of increased flow and dilution-related water quality improvements, such as smallmouth bass.

- reduction in abundance of headwater species that exist principally in the headwater area, such as redfin pickerel, hybrid sunfish, and pumpkinseed.

- increase in distribution or abundance of species less tolerant of pollution because of downstream water quality improvements, such as tessellated darter, redbreast sunfish.

alteration of the length, weight, growth rate of some species as a result of water quality improvement and increased flow, such as white sucker, redbreast sunfish, and perhaps smallmouth bass and spotfin shiner.

Diversion of water into the East Branch also could result in a reduction of periphyton productivity in the upper section during the summer low flow period. In total, the entire aquatic community of the upper section could be affected by the inflow of diversion water during the normally low flow period. The exception will be the approximately 4 km of headwater creek upstream of the diversion point.

The middle and lower creek sections should be altered beneficially by the inflow of diversion water as a result of improved water quality and flow stabilization during low flow periods. This could give some fishes more access to areas of the stream they do not now inhabit. A more stable flow condition also could be very beneficial to spawning and to the survival of eggs and larvae by reducing the chance of exposure and mortality during low flow. More area could be available for spawning and nursery activities, especially if diversion starts before or early in the spawning season. Generally, the areas of the creek more useable for fishing (middle and lower sections) should experience some improvement in aquatic productivity and in the fishery resource as a result of improved water quality and a more stable year-round flow regime.

Introduction of Delaware River species into the East Branch could occur as a result of water withdrawal at Point Pleasant. Many of the species found in the river also are found in the creek. Most of the organisms introduced into the creek, therefore, would be species already living there. These organisms would become established in the East Branch only if suitable habitat is found and competition with resident species allows. Suitable habitat (suitable area, flow, and water quality) may exist only in the lower section for some species. To enter the East Branch, fish larvae would have to survive pumping at Point Pleasant and transport through the system of pipes. Introduction of macroinvertebrate drift is possible because some species may be far less sensitive to the pumpage/transport stresses than larval fishes. It is also possible that a macroinvertebrate community could become established in Bradshaw Reservoir. The reservoir also could provide suitable habitat for Corbicula sp. if it should enter the Point Pleasant area and be withdrawn as larvae. A reproducing benthic population in the reservoir could supply drift to the East Branch. An established benthic population in the reservoir also could act as a food source and contribute to survival of fishes that enter there.

In summary, diversion of water from the Delaware River into the East Branch of Perkiomen Creek will affect the biotic community of the creek. The upper section will be affected most and will be altered from its present condition. Alteration of this section will result in a loss of habitat diversity and heterogeneity of the East Branch system. The other downstream areas should experience habitat improvement (water quality improvement and flow stability). Productivity and the fishery potential of the middle and lower sections should improve (i.e., benefit from diversion). The Commonwealth's designated water uses for the East Branch as a whole will not be significantly affected. The studies conducted on the East Branch since the FES-CP was issued have supplied a detailed data base that confirms the 1973 DRBC conclusions with which the AEC staff agreed. These data also supply a description of present conditions of the creek (including bioindicators of change) that will serve as a yardstick against which conditions can be measured.

5.5.2.4 Main Stem of Perkiomen Creek

The potential impacts to the aquatic resources of Perkiomen Creek from diversion of water and withdrawals at Graterford were discussed in the FES-CP (Section 5.4.2). The intake design proposed at that time consisted of a shoreline structure with vertical traveling screens (see Section 4.2.4 of this statement). In summary, the FES-CP examined the impacts of diversion of water into the creek and of withdrawals at Graterford and found

(1) The presence of the intake posed a threat to the most extensive concentrations of game fish and panfish in the creek study area.

(2) The impact of impingement and entrainment had to be minimized by appropriate design.

(3) The impact of impingement (should it prove to be a serious problem) had to be alleviated by alternate intake designs.

(4) The overall effect of the proposed pumpages into the creek would be beneficial, if the effects of impingement and entrainment at the intake were not severe.

The intake design has been changed since the FES-CP was issued. The use of cylindrical wedge-wire screens essentially eliminates impingement of fishes as a source of impact. Entrainment of fish larvae has not been eliminated by the new design, but it will substantially reduce the impact of entrainment compared to that predicted for the previous proposal. The Graterford intake will be operated essentially throughout the entire spawning season, withdrawing relatively large proportions of the creek flow (see Section 4.2.4); thus the potential for entrainment impact remains high (ER-OL Section 5.1.3.2.2). The most abundant larval fishes near Graterford have been carp, minnows, and sunfishes. Carp and sunfishes are among the recreational fishery species of the creek (Section 4.3.4.2.5). The applicant calculated the potential entrainment losses of fish larvae based on larval densities measured during 1975 and 1976, while assuming average withdrawal rates of about 49 to 53 ft^3/s (ER-OL Section 5.1.3.2.2 and ER-OL Table 5.1-9). For 1975, daily losses during July-August were 384 to 10,190 larvae, representing entrainment rates of 13 to 42% of the drift passing the intake. During 1976, daily losses in April-August were 974 to 80,290 larvae, representing entrainment rates of drifting larvae of 13 to 45%. The 1976 estimates are based on 10 sampling dates during a 132-day period. Using the mean number of larvae potentially entrained per day (calculated from ER-OL Table 5.1-9), the NRC staff estimates that the total entrainment loss for the period would have been about 1.9×10^6 larvae. This worst case analysis assumes that all larvae within the influence of the intake were withdrawn with the cooling water. The wedgewire screens should exclude entrainment of a substantial portion of larvae, especially older and more mobile ones. The large volumes of water withdrawn (relative to stream flow) throughout the spawning season, however, suggests that there is a potential for entrainment losses at Graterford and associated downstream impacts resulting from these losses. It also suggests that conversion from a shoreline intake (with traveling screens) to a state-of-the-art mid-stream wedgewire intake is appropriate for Perkiomen Creek.

Water withdrawal will entrain plankton and macroinvertebrate drift; however, population impacts are not expected to be adverse. These biotic groups have a potential for rapid spatial recovery in flowing streams. Plankton groups generally have rapid reproductive rates that can compensate for minor losses.

Diversion flow into Perkiomen Creek is not expected to substantially affect the biotic resources. Overall, more water will be diverted into the creek than will be removed at Graterford. A net gain in flow during low flow periods would have some beneficial effects to the creek.

Based on the analysis discussed above, the NRC staff finds that the present intake design is responsive to the concerns raised in the FES-CP. Impingement has been eliminated as a source of impact, and the entrainment impact potential has been greatly reduced, although losses are expected. The Commonwealth's designated water uses for the creek as a whole will not be significantly affected.

5.5.2.5 Aquatic Resource Impact Summary

The operation of Limerick will require four water bodies to provide source and receiving waters for condenser cooling. The Schuylkill River will be the primary source of water for station use. Supplemental water will be withdrawn from the Delaware River and transported via the East Branch of Perkiomen Creek into the Main Stem of Perkiomen Creek where it will be withdrawn for use by Limerick. This will require intake structures on three water bodies (Delaware River, Perkiomen Creek, and Schuylkill River). All effluents will be discharged to the Schuylkill River. Supplemental water normally will be required during the low flow period from about April through November. Although impacts to other organisms are considered, because this period encompasses virtually the entire fish spawning season of all four water bodies, fishes and the fisheries are the biotic resources of most concern to the NRC staff.

During the low flow period, withdrawals from the Schuylkill will be reduced so that all consumptive water will be supplied by diverting Delaware River water to Limerick. The small volume of withdrawal from the Schuylkill River during that period will be via a conventional intake structure with traveling screens. Because water will be withdrawn from Perkiomen Creek and the Delaware River throughout the spawning season, the use of a state-of-the-art intake design (cylindrical wedge-wire screens) to minimize impacts has been proposed. This is appropriate, especially for Perkiomen Creek where proportionally large volumes of water will be used. During the productive period of spawning, a conventional intake will remove a relatively small volume of water from the Schuylkill River, while state-of-the-art intakes remove water from the other two systems.

The impact potentials of the four water bodies are as follows:

(1) Schuylkill River: Localized minor effects are possible from impingement and entrainment of fishes and from thermal effluents, adding stresses to an already stressed system.

(2) Delaware River: No detectable effects are projected; the present intake design significantly reduces the impact potential, as compared with the design proposed at the CP stage. Of the four water bodies to be used, the Delaware River appears to have the least potential for impact.

(3) East Branch of Perkiomen Creek: Diversion of water into the creek will alter the upper section from its present seasonally intermittent headwater

condition to a more downstream-like steady-flowing state. The middle and lower creek sections will be affected beneficially by water quality improvement. Delaware River biota could be introduced into the creek.

(4) Perkiomen Creek: Localized effects are possible from entrainment of fish larvae; the present intake design significantly reduces the potential impact, as compared with the design proposed at the CP stage.

Thus, on the basis of the analysis the NRC staff finds that the Commonwealth's designated water uses will not be significantly affected.

5.6 Threatened and Endangered Species

5.6.1 Terrestrial

See the discussion in Section 4.3.5.1 above.

5.6.2 Aquatic

The potential impact of the withdrawal of water at Point Pleasant on endangered shortnose sturgeon of Delaware River was addressed by the NRC ASLB in its March 1983 Partial Initial Decision on Supplementary Cooling Water System Contentions. The ASLB reviewed the evidence from many sources, including NRC staff testimony; testimony of state and Federal experts; testimony of experts on behalf of intervenors; and a biological opinion prepared by the National Marine Fisheries Service pursuant to requirements of the Endangered Species Act, as amended. Based on the testimony offered in the October 1982 pre-hearing conference, the ASLB found that there will be no significant impact to any life stage of shortnose sturgeon (NRC ASLB, 1983, Findings 75-94).

5.7 Historic and Archeologic Impacts

The NRC staff concludes that the operation and maintenance of the Limerick station will have no significant impacts on the sites listed or eligible for listing in the National Register of Historic Places, with the exception of possible impacts along the transmission corridors. Upon receipt of the reports of the archeologic and historic surveys of the transmission routes, the NRC staff will review the results in consultation with the State Historic Preservation Officer. With regard to the Point Pleasant pumping station, a memorandum of agreement was signed by the U.S. Army Corps of Engineers, the Pennsylvania State Historic Preservation Officer, and the Advisory Council on Historic Preservation. This agreement concerns the permit application by the Neshaminy Water Resources Authority for the station and stipulates the conditions the Corps was required to have included in its permit so that adverse construction and operation impacts of the station on the properties listed or eligible for listing in the National Register may be avoided, minimized, or mitigated. The only potential impact with which the NRC staff is directly involved is the effect of noise, which is analyzed in Section 5.12.

5.8 Socioeconomic Impacts

The socioeconomic impacts of station operation are analyzed in Sections 5.7 and 12.2 of the FES-CP. Changes that have occurred since that report was issued include an increase in the estimated operating work force to about 724 people.

This includes 599 Philadelphia Electric Company employees and 125 contractor employees. The work force is estimated to have a salary of $25.6 million in 1982 dollars (letter from J. S. Kemper, PECo, to A. Schwencer, NRC, dated December 20, 1983). The NRC staff does not expect the operating workers or their families to have any significant impact on public or private facilities.

Purchases of goods and services required for the operation of Limerick that are expected to occur locally include miscellaneous electric, welding, and mechanical supplies, additional construction, waste removal, food purchases, and the like. The applicant was not able to provide a dollar estimate of these purchases, but the NRC staff expects the purchases to be small compared to the size of the local economy and not to be a significant impact.

Tax payments are considered as indirect benefits of the station's operation because they are transfer payments. In Pennsylvania, public utilities do not pay local property taxes; however, Pennsylvania levies a public utility realty tax. The applicant estimates this tax to be $15.7 million in 1990 (1982 dollars) for the Limerick Station, while the actual Public Utility Realty assessment for 1982 was $12.6 million (letter from J. S. Kemper, PECo, to A. Schwencer, NRC, dated December 20, 1983).

5.9 Radiological Impacts

5.9.1 Regulatory Requirements

Nuclear power reactor licensees in the United States must comply with certain regulatory requirements in order to operate. The permissible levels of radiation in unrestricted areas and releases of radionuclides in effluents to unrestricted areas are established in 10 CFR 20, Standards for Protection Against Radiation. These regulations specify limits on levels of radiation and on concentrations of radionuclides in the facility's effluent releases to the air and water (above natural background). The radiation protection standards of 10 CFR 20 specify limitations on whole body radiation doses to members of the general public in unrestricted areas at three levels: 500 millirems in any calendar year, 100 millirems in any seven consecutive days, and 2 millirems in any one hour. These limits are consistent with national and international standards, in terms of protecting public health and safety.

In addition to the Radiation Protection Standards of 10 CFR 20, there are recorded in 10 CFR 50.36a license requirements that are to be imposed on licensees in the form of Technical Specifications on Effluents from Nuclear Power Reactors to keep releases of radioactive materials to unrestricted areas during normal operations, including expected operational occurrences, as low as is reasonably achievable (ALARA). Appendix I of 10 CFR 50 provides numerical guidance on dose-design objectives for LWRs to meet this ALARA requirement. Applicants for permits to construct and for licenses to operate an LWR shall provide reasonable assurance that the following calculated dose-design objectives will be met for all unrestricted areas: 3 mrems/year to the total body or 10 mrems/year to any organ from all pathways of exposure from liquid effluents; 10 mrads/year gamma radiation or 20 mrads/year beta radiation air dose from gaseous effluents near ground level--and/or 5 mrems/year to the total body or 15 mrems/year to the skin from gaseous effluents; and 15 mrems/year to any organ from all pathways of exposure from airborne effluents that include the radioiodines, carbon-14, tritium, and the particulates.

Experience with the design, construction, and operation of nuclear power reactors indicates that compliance with these design objectives will keep average annual releases of radioactive material in effluents at small percentages of the limits specified in 10 CFR 20 and, in fact, will result in doses generally below the dose-design objective values of Appendix I. At the same time, the licensee is permitted the flexibility of operation, compatible with considerations of health and safety, to ensure that the public is provided a dependable source of power, even under unusual operating conditions that may temporarily result in releases higher than such small percentages but still well within the limits specified in 10 CFR 20.

In addition to the impact created by facility radioactive effluents as discussed above, within the NRC policy and procedures for environmental protection described in 10 CFR 51 there are generic treatments of environmental effects of all aspects of the Uranium Fuel Cycle. These environmental data have been summarized in Table S-3 and are discussed later in this report in Section 5.10. In the same manner the environmental impact of transportation of fuel and waste to and from an LWR is summarized in Table S-4 and presented in Section 5.9.3 of this report.

Recently an additional operational requirement for Uranium Fuel Cycle Facilities including nuclear power plants was established by the Environmental Protection Agency in 40 CFR 190. This regulation limits annual doses (excluding radon and daughters) for members of the public to 25 mrems total body, 75 mrems thyroid, and 25 mrems other organs from all fuel-cycle facility contributions that may impact a specific individual in the public.

5.9.2 Operational Overview

During normal operations of Limerick, small quantities of radioactivity (fission and activation products) will be released to the environment. As required by NEPA, the NRC staff has determined the estimated dose to members of the public outside of the plant boundaries as a result of the radiation from these radioisotope releases and relative to natural-background-radiation dose levels.

These facility-generated environmental dose levels are estimated to be very small because of both the plant design and the development of a program that will be implemented at the facility to contain and control all radioactive emissions and effluents. As mentioned in Section 4.2.5, highly efficient radioactive-waste management systems are incorporated into the plant design. These systems are designed to remove most of the fission-product radioactivity that is assumed to leak, in small amounts, from the fuel, as well as most of the activation-product radioactivity produced by neutrons in the reactor-core vicinity. The effectiveness of these systems will be measured by process and effluent radiological monitoring systems that permanently record the amounts of radioactive constituents remaining in the various airborne and waterborne process and effluent streams. The amounts of radioactivity released through vents and discharge points to be further dispersed and diluted to points outside the plant boundaries are to be recorded and published semiannually in the Radioactive Effluent Release Reports for the facility.

The small amounts of airborne effluents that are released will diffuse in the atmosphere in a fashion determined by the meteorological conditions existing at the time of release and are generally much dispersed and diluted by the time they reach unrestricted areas that are open to the public. Similarly, the small amounts of waterborne effluents released will be diluted with plant waste water and then further diluted as they mix with the Schuylkill River beyond the plant boundaries.

Radioisotopes in the facility's effluents that enter unrestricted areas will produce doses through their radiations to members of the general public in a manner similar to the way doses are produced from background radiations (that is, cosmic, terrestrial, and internal radiations), which also include radiation from nuclear-weapons fallout. These radiation doses can be calculated for the many potential radiological-exposure pathways specific to the environment around the facility, such as direct-radiation doses from the gaseous plume or liquid effluent stream outside of the plant boundaries, or internal-radiation-dose commitments from radioactive contaminants that might have been deposited on vegetation, or in meat and fish products eaten by people, or that might be present in drinking water outside the plant or incorporated into milk from cows at nearby farms.

These doses, calculated for the "maximally exposed" individual (that is, the hypothetical individual potentially subject to maximum exposure), form the basis of the NRC staff's evaluation of impacts. Actually, these estimates are for a fictitious person because assumptions are made that tend to overestimate the dose that would accrue to members of the public outside the plant boundaries. For example, if this "maximally exposed" individual were to receive the total body dose calculated at the plant boundary as a result of external exposure to the gaseous plume, he/she is assumed to be physically exposed to gamma radiation at that boundary for 70% of the year, an unlikely occurrence.

Site-specific values for various parameters involved in each dose pathway are used in the calculations. These include calculated or observed values for the amounts of radioisotopes released in the gaseous and liquid effluents, meteorological information (for example, wind speed and direction) specific to the site topography and effluent release points, and hydrological information pertaining to dilution of the liquid effluents as they are discharged.

An annual land census will identify changes in the use of unrestricted areas to permit modifications in the programs for evaluating doses to individuals from principal pathways of exposure. This census specification will be incorporated into the Radiological Technical Specifications and satisfies the requirements of Section IV.B.3 of Appendix I to 10 CFR 50. As use of the land surrounding the site boundary changes, revised calculations will be made to ensure that the dose estimate for gaseous effluents always represents the highest dose that might possibly occur for any individual member of the public for each applicable foodchain pathway. The estimate considers, for example, where people live, where vegetable gardens are located, and where cows are pastured.

An extensive radiological environmental monitoring program, designed specifically for the environs of Limerick, provides measurements of radiation and radioactive contamination levels that exist outside of the facility boundaries both before and after operations begin. In this program, offsite radiation levels are continuously monitored with thermoluminescent detectors (TLDs). In addition, measurements are made on a number of types of samples from the surrounding area to determine the possible presence of radioactive contaminants which, for example, might be deposited on vegetation, be present in drinking water outside the plant, or be incorporated into cows' milk from nearby farms. The results for all radiological environmental samples measured during a calendar year of operation are recorded and published in the Annual Radiological Environmental Operating Report for the facility. The specifics of the final operational-monitoring program and the requirement for annual publication of the monitoring results will be incorporated into the operating license Radiological Technical Specifications for the Limerick facility.

5.9.3 Radiological Impacts from Routine Operations

5.9.3.1 Radiation Exposure Pathways: Dose Commitments

The potential environmental pathways through which persons may be exposed to radiation originating in a nuclear power reactor are shown schematically in Figure 5.4. When an individual is exposed through one of these pathways, the dose is determined in part by the amount of time he or she is in the vicinity of the source, or the amount of time the radioactivity inhaled or ingested is retained in his or her body. The actual effect of the radiation or radioactivity is determined by calculating the dose commitment. The annual dose commitment is calculated to be the total dose that would be received over a 50-year period, following the intake of radioactivity for 1 year under the conditions existing 20 years after the station begins operation. (Calculation for the 20th year, or midpoint of station operation, represents an average exposure over the life of the plant.) However, with few exceptions, most of the internal dose commitment for each nuclide is given during the first few years after exposure because of the turnover of the nuclide by physiological processes and radioactive decay. There are a number of possible exposure pathways to humans that are appropriate to be studied to determine the impact of routine releases from the Limerick site on members of the general public living and working outside of the site boundaries, and whether the releases projected at this point in the licensing process will in fact meet regulatory requirements. A detailed listing of these exposure pathways would include external radiation exposure from the gaseous effluents, inhalation of iodines and particulate contaminants in the air, drinking milk from a cow or eating meat from an animal that feeds on open pasture near the site on which iodines or particulates may have deposited, eating vegetables from a garden near the site that may be contaminated by similar deposits, and drinking water or eating fish caught near the point of discharge of liquid effluents.

Other less important pathways include: external irradiation from radionuclides deposited on the ground surface; eating animals and food crops raised near the site using irrigation water that may contain liquid effluents; shoreline, boating, and swimming activities near lakes or streams that may be contaminated by effluents; drinking potentially contaminated water; and direct radiation from within the plant itself.

Calculations of the effects for most pathways are limited to a radius of 80 km (50 miles). This limitation is based on several facts. Experience, as demonstrated by calculations, has shown that all individual dose commitments (>0.1 mrem/year) for radioactive effluents are accounted for within a radius of 80 km from the plant. Beyond 80 km the doses to individuals are smaller than 0.1 mrem/year, which is far below natural-background doses, and the doses are subject to substantial uncertainty because of limitations of predictive mathematical models.

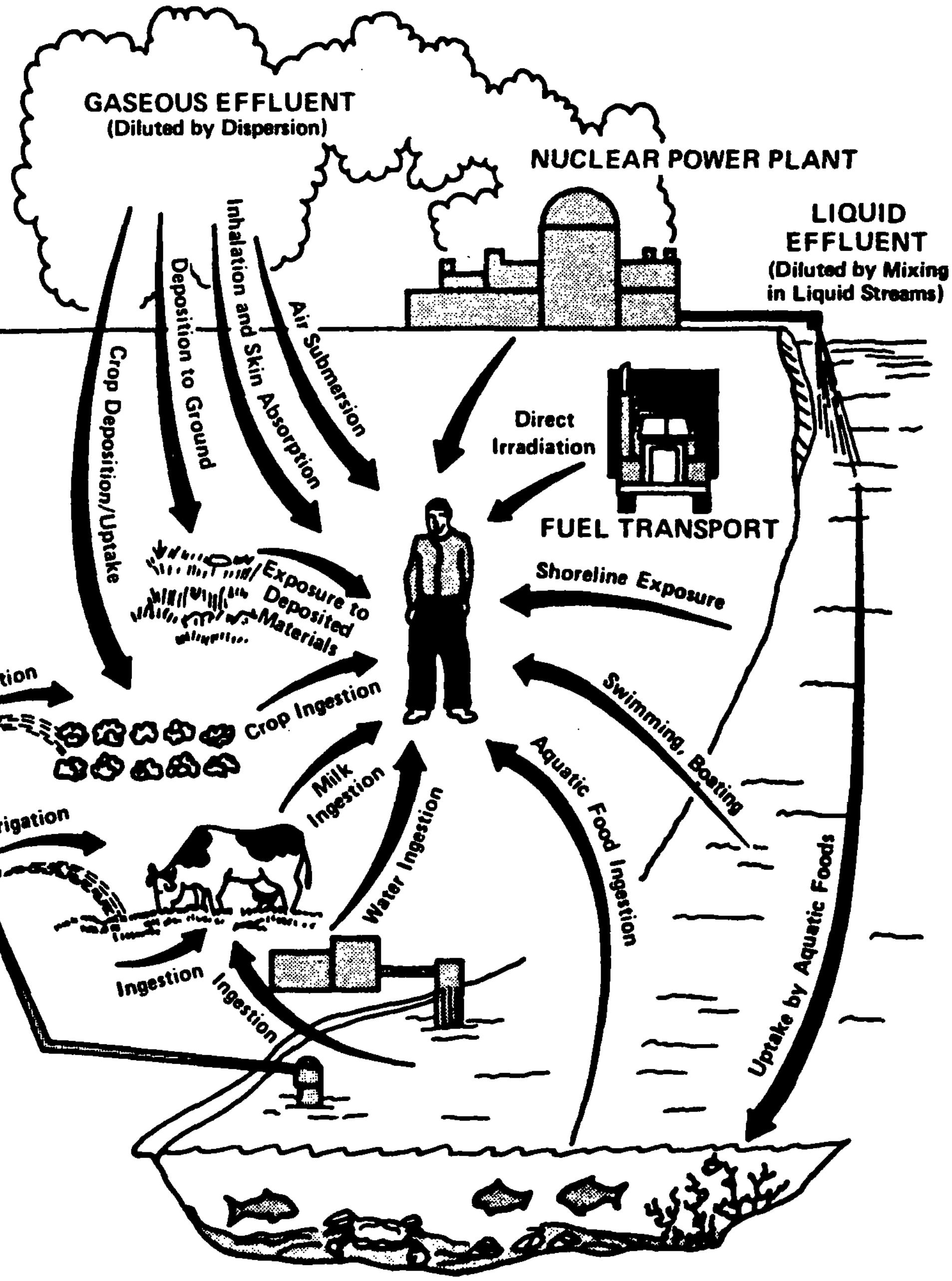


Figure 5.4 Potentially meaningful exposure pathways to individuals

The NRC staff has made a detailed study of all of the above important pathways and has evaluated the radiation-dose commitments both to the plant workers and the general public for these pathways resulting from routine operation of the facility. A discussion of these evaluations follows.

5.9.3.1.1 Occupational Radiation Exposure for Boiling Water Reactors (BWRs)

Most of the dose to nuclear plant workers results from external exposure to radiation coming from radioactive materials outside of the body rather than from internal exposure from inhaled or ingested radioactive materials. Experience shows that the dose to nuclear plant workers varies from reactor to reactor and from year to year. For environmental-impact purposes, it can be projected by using the experience to date with modern BWRs. Recently licensed 1000-MWe BWRs are operated in accordance with the post-1975 regulatory requirements and guidance that place increased emphasis on maintaining occupational exposure at nuclear power plants ALARA. These requirements and guidance are outlined primarily in 10 CFR 20, Standard Review Plan Chapter 12 (NUREG-0800), and RG 8.8, "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be as Low as Is Reasonably Achievable."

The applicant's proposed implementation of these requirements and guidelines is reviewed by the NRC staff during the licensing process, and the results of that review are reported in the staff's SER. The license is granted only after the review indicates that an ALARA program can be implemented. In addition, regular reviews of operating plants are performed to determine whether the ALARA requirements are being met.

Average collective occupational dose information for 177 BWR reactor years of operation is available for those plants operating between 1974 and 1981.* These data indicate that the average reactor annual collective dose at BWRs has been about 790 person-rems, although some plants have experienced average annual collective doses as high as 1660 person-rems over their operating lifetimes (NUREG-0713, Vol 3). These dose averages are based on widely varying yearly doses at BWRs. For example, for the period mentioned above, annual collective doses for BWRs have ranged from 44 to 3626 person-rems per reactor. However, the average annual dose per nuclear plant worker of about 0.8 rem (ibid.) has not varied significantly during this period. The worker dose limit, established by 10 CFR 20, is 3 rems/quarter (if the average dose over the worker lifetime is being controlled to 5 rems/year) or 1.25 rems/quarter if it is not.

The wide range of annual collective doses experienced at BWRs in the United States results from a number of factors such as the amount of required maintenance and the amount of reactor operations and inplant surveillance. Because these factors can vary widely and unpredictably, it is impossible to determine in advance a specific year-to-year annual occupational radiation dose for a particular plant over its operating lifetime. There may on occasion be a need for relatively high collective occupational doses, even at plants with radiation protection programs designed to ensure that occupational radiation doses will be kept ALARA.

In recognition of the factors mentioned above, the NRC staff's occupational dose estimates for environmental impact purposes for Limerick are based on the assumption that the facility will experience the annual average occupational

*The year 1974 was chosen as a starting date because the dose data for years prior to 1974 are primarily from reactors with average rated capacities below 500 MWe.

dose for BWRs to date, which is approximately 790 person-rems. The applicant has projected in FSAR Table 12.4-9 that the collective occupational doses for each unit at Limerick will be 627 person-rems, but annual collective doses could average as much as 1660 person-rems over the life of the plant, based on NRC staff estimates.

In addition to the occupational radiation exposures discussed above, during the period between the initial power operation of Unit 1 and the similar startup of Unit 2, construction personnel working on Unit 2 will potentially be exposed to sources of radiation from the operation of Unit 1. The applicant has estimated that the integrated dose to construction personnel, over a period of 2 years, will be about 41 person-rems. This radiation exposure will result predominantly from radiation due to radioactive nitrogen-16 in the steam passing through the the Unit 1 turbine and penetrating the turbine, the building, and the air to where workers may be, and gaseous effluents from Unit 1. Based on experience with other BWRs, the NRC staff finds that the applicant's estimate is reasonable. A detailed breakdown of the integrated dose to the construction workers by the location of their work and its duration is given in FSAR Table 12.4-15.

The average annual dose of about 0.8 rem per nuclear-plant worker at operating BWRs and PWRs has been well within the limits of 10 CFR 20. However, for impact evaluation, the NRC staff has estimated the risk to nuclear-power-plant workers and compared it in Table 5.6 to published risks for other occupations. Based on these comparisons, the NRC staff concludes that the risk to nuclear-plant workers from plant operation is comparable to the risks associated with other occupations.

In estimating the health effects resulting from both offsite (see Section 5.9.3.2) and occupational radiation exposures as a result of normal operation of this facility, the NRC staff used somatic (cancer) and genetic risk estimators that are based on widely accepted scientific information. Specifically, the staff's estimates are based on information compiled by the National Academy of Sciences' Advisory Committee on the Biological Effects of Ionizing Radiation (BEIR I). The estimates of the risks to workers and the general public are based on conservative assumptions (that is, the estimates are probably higher than the actual number). The following risk estimators were used to estimate health effects: 135 potential deaths from cancer per million person-rems and 258 potential cases of all forms of genetic disorders per million person-rems. The cancer-mortality risk estimates are based on the "absolute risk" model described in BEIR I. Higher estimates can be developed by use of the "relative risk" model along with the assumption that risk prevails for the duration of life. Use of the "relative risk" model would produce risk values up to about four times greater than those used in this report. The staff regards the use of the "relative risk" model values as a reasonable upper limit of the range of uncertainty. The lower limit of the range would be zero because health effects have not been detected at doses in this dose-rate range. The number of potential nonfatal cancers would be approximately 1.5 to 2 times the number of potential fatal cancers, according to the 1980 report of the National Academy of Sciences' Advisory Committee on the Biological Effects of Ionizing Radiation (BEIR III).

Values for genetic risk estimators range from 60 to 1500 potential cases of all forms of genetic disorders per million person-rems (BEIR I). The value of 258 potential cases of all forms of genetic disorders is equal to the sum of

Table 5.6 Incidence of job-related mortalities

Occupational Group	Mortality Rates (premature deaths per 10^5 person-years)
Underground metal miners*	~1300
Uranium miners*	420
Smelter workers*	190
Mining**	61
Agriculture, forestry, and fisheries**	35
Contract construction**	33
Transportation and public utilities**	24
Nuclear-plant worker***	23
Manufacturing**	7
Wholesale and retail trade**	6
Finance, insurance, and real estate**	3
Services**	3
Total private sector**	10

*The President's Report on Occupational Safety and Health, "Report on Occupational Safety and Health by the U.S. Department of Health, Education, and Welfare," E. L. Richardson, Secretary, May 1972.

**U.S. Bureau of Labor Statistics, "Occupational Injuries and Illness in the United States by Industry, 1975," Bulletin 1981, 1978.

***The nuclear-plant workers' risk is equal to the sum of the radiation-related risk and the nonradiation-related risk. The estimated occupational risk associated with the industry-wide average radiation dose of 0.8 rem is about 11 potential premature deaths per 10^5 person-years due to cancer, based on the risk estimators described in the following text. The average non-radiation-related risk for seven U.S. electrical utilities over the period 1970-1979 is about 12 actual premature deaths per 10^5 person-years as shown in Figure 5 of the paper by R. Wilson and E. S. Koehl, "Occupational Risks of Ontario Hydro's Atomic Radiation Workers in Perspective," presented at Nuclear Radiation Risks, A Utility-Medical Dialog, sponsored by the International Institute of Safety and Health in Washington, D.C., September 22-23, 1980. (Note that the estimate of 11 radiation-related premature cancer deaths describes a potential risk rather than an observed statistic.)

the geometric means of the risk of specific genetic defects and the risk of defects with complex etiology.

The preceding values for risk estimators are consistent with the recommendations of a number of recognized radiation-protection organizations, such as the International Commission on Radiological Protection (ICRP, 1977), the National Council on Radiation Protection and Measurement (NCRP, 1975), the National Academy of Sciences (BEIR III), and the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR, 1982).

The risk of potential fatal cancers in the exposed work-force population at Units 1 and 2 of the Limerick facility is estimated as follows: multiplying the annual plant-worker-population dose of about 1254 person-rems given in FSAR Table 12.4-9 by the somatic risk estimator, the staff estimates that about 0.17 cancer death may occur in the total exposed population. The value of 0.17 cancer death means that the probability of 1 cancer death over the lifetime of the entire work force as a result of 1 year of facility operation is about 17 chances in 100. The risk of potential genetic disorders attributable to exposure of the workforce is a risk borne by the progeny of the entire population and is thus properly considered as part of the risk to the general public.

5.9.3.1.2 Public Radiation Exposure

Transportation of Radioactive Materials

The transportation of "cold" (unirradiated) nuclear fuel to the reactor, of spent irradiated fuel from the reactor to a fuel reprocessing plant, and of solid radioactive wastes from the reactor to waste burial grounds is considered in 10 CFR 51.20. The contribution of the environmental effects of such transportation to the environmental costs of licensing the nuclear power reactor is set forth in Summary Table S-4 from 10 CFR 51.20, reproduced herein as Table 5.7. The cumulative dose to the exposed population as summarized in Table S-4 is very small when compared to the annual collective dose of about 60,000 person-rems to this same population or 26,000,000 person-rems to the U.S. population from background radiation.

Direct Radiation for BWRs

Radiation fields are produced around nuclear plants as a result of radioactivity within the reactor and its associated components, as well as a result of radioactive-effluent releases. Although the components are shielded, dose rates observed around BWR plants from these plant components have varied from undetectable levels to values on the order of 100 mrems per year at onsite locations where members of the general public were allowed. For newer BWR plants with a standardized design, dose rates have been estimated using special calculational modeling techniques. The calculated cumulative dose to the exposed population from such a facility would be much less than 1 person-rem per year per unit, insignificant when compared with the natural background dose as set forth in Table D-7.

Low-level radioactivity storage containers outside the plant are estimated to make a dose contribution at the site boundary of less than 0.1% of that due to the direct radiation described above.

Table 5.7 (Summary Table S-4) Environmental impact of transportation of fuel and waste to and from one light-water-cooled nuclear power reactor[1]

NORMAL CONDITIONS OF TRANSPORT

	Environmental impact
Heat (per irradiated fuel cask in transit)	250,000 Btu/hr.
Weight (governed by Federal or State restrictions)	73,000 lbs. per truck; 100 tons per cask per rail car.
Traffic density:	
Truck	Less than 1 per day.
Rail	Less than 3 per month.

Exposed population	Estimated number of persons exposed	Range of doses to exposed individuals [2] (per reactor year)	Cumulative dose to exposed population (per reactor year) [3]
Transportation workers	200	0.01 to 300 millirem	4 man-rem.
General public:			
Onlookers	1,100	0.003 to 1.3 millirem	3 man-rem.
Along Route	600,000	0.0001 to 0.06 millirem	

ACCIDENTS IN TRANSPORT

	Environmental risk
Radiological effects	Small
Common (nonradiological) causes	1 fatal injury in 100 reactor years; 1 nonfatal injury in 10 reactor years; $475 property damage per reactor year.

[1] Data supporting this table are given in the Commission's "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants," WASH-1238, December 1972, and Supp. I, NUREG-75/038 April 1975. Both documents are available for inspection and copying at the Commission's Public Document Room, 1717 H St. NW., Washington, D.C., and may be obtained from National Technical Information Service, Springfield, Va. 22161. WASH-1238 is available from NTIS at a cost of $5.45 (microfiche, $2.25) and NUREG-75/038 is available at a cost of $3.25 (microfiche, $2.25).

[2] The Federal Radiation Council has recommended that the radiation doses from all sources of radiation other than natural background and medical exposures should be limited to 5,000 millirem per year for individuals as a result of occupational exposure and should be limited to 500 millirem per year for individuals in the general population. The dose to individuals due to average natural background radiation is about 130 millirem per year.

[3] Man-rem is an expression for the summation of whole body doses to individuals in a group. Thus, if each member of a population group of 1,000 people were to receive a dose of 0.001 rem (1 millirem), or if 2 people were to receive a dose of 0.5 rem (500 millirem) each, the total man-rem dose in each case would be 1 man-rem.

[4] Although the environmental risk of radiological effects stemming from transportation accidents is currently incapable of being numerically quantified, the risk remains small regardless of whether it is being applied to a single reactor or a multireactor site.

Radioactive-Effluent Releases: Air and Water

Limited quantities of radioactive effluents will be released to the atmosphere and to the hydrosphere during normal operations. Estimates of site-specific radioisotope-release values have been developed on the basis of estimates regarding fuel performance and the descriptions of operational and radwaste systems in the applicant's ER and FSAR and by using the calculational models and parameters developed by the NRC staff in NUREG-0016. These have been supplemented by extensive use of the applicant's site and environmental data in the ER and in subsequent answers to NRC staff questions, and should be studied to obtain an understanding of airborne and waterborne releases from the facility.

These radioactive effluents are then diluted by the air and water into which they are released before they reach areas accessible to the general public.

Radioactive effluents can be divided into several groups. Among the airborne effluents, the radioisotopes of the fission product noble gases, krypton and xenon, as well as of argon, do not deposit on the ground nor are they absorbed and accumulated within living organisms; therefore, the noble gas effluents act primarily as a source of direct external radiation emanating from the effluent plume. Dose calculations are performed for the site boundary where the highest external-radiation doses to a member of the general public as a result of gaseous effluents have been estimated to occur; these include the total body and skin doses as well as the annual beta and gamma air doses from the plume at that boundary location.

Another group of airborne radioactive effluents--the fission product radioiodines, as well as carbon-14 and tritium--are also gaseous, but these tend to be deposited on the ground and/or inhaled into the body during breathing. For this class of effluents, estimates of direct external-radiation doses from deposits on the ground, and of internal radiation doses to total body, thyroid, bone, and other organs from inhalation and from vegetable, milk, and meat consumption are made. Concentrations of iodine in the thyroid and of carbon-14 in bone are of particular significance here.

A third group of airborne effluents, consisting of particulates that remain after filtration of airborne effluents in the plant prior to release, includes fission products such as cesium and barium and activated corrosion products such as cobalt and chromium. The calculational model determines the direct external radiation dose and the internal radiation doses for these contaminants through the same pathways as described above for the radioiodines, carbon-14, and tritium. Doses from the particulates are combined with those of the radioiodines, carbon-14, and tritium for comparison to one of the design objectives of Appendix I to 10 CFR 50.

The waterborne-radioactive-effluent constituents could include fission products such as nuclides of strontium and iodine; activation products, such as nuclides of sodium and manganese; and tritium as tritiated water. Calculations estimate the internal doses (if any) from fish consumption, from water ingestion (as drinking water), and from eating of meat or vegetables raised near the site on irrigation water, as well as any direct external radiation from recreational use of the water near the point of discharge.

The release values for each group of effluents, along with site-specific meteorological and hydrological data, serve as input to computerized radiation-dose models that estimate the maximum radiation dose that would be received outside the facility via a number of pathways for individual members of the public, and for the general public as a whole. These models and the radiation-dose calculations are discussed in the October 1977 Revision 1 of RG 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," and in Appendix B of this statement.

Examples of site-specific dose assessment calculations and discussions of parameters involved are given in Appendix D. Doses from all airborne effluents except the noble gases are calculated for individuals at the location (for example, the site boundary, garden, residence, milk cow, and meat animal) where the highest radiation dose to a member of the public has been established from all applicable pathways (such as ground deposition, inhalation, vegetable consumption, cow milk consumption, or meat consumption). Only those pathways associated with airborne effluents that are known to exist at a single location are combined to calculate the total maximum exposure to an exposed individual. Pathway doses associated with liquid effluents are combined without regard to any single location, but they are assumed to be associated with maximum exposure of an individual through other than gaseous-effluent pathways.

5.9.3.2 Radiological Impact on Humans

Although the doses calculated in Appendix D are based primarily on radioactive-waste treatment system capability and are below the Appendix I design objective values, the actual radiological impact associated with the operation of the facility will depend, in part, on the manner in which the radioactive-waste treatment system is operated. Based on its evaluation of the potential performance of the ventilation and radwaste treatment systems, the NRC staff has concluded that the systems as now proposed are capable of controlling effluent releases to meet the dose-design objectives of Appendix I to 10 CFR 50.

Operation of the Limerick facility will be governed by operating license Technical Specifications that will be based on the dose-design objectives of Appendix I to 10 CFR 50. Because these design-objective values were chosen to permit flexibility of operation while still ensuring that plant operations are ALARA, the actual radiological impact of plant operation may result in doses close to the dose-design objectives. Even if this situation exists, the individual doses for the member of the public subject to maximum exposure will still be very small when compared to natural background doses (∿100 mrems/year) or the dose limits (500 mrems/year - total body) specified in 10 CFR 20 as consistent with considerations of the health and safety of the public. As a result, the NRC staff concludes that there will be no measurable radiological impact on any member of the public from routine operation of the Limerick facility.

Operating standards of 40 CFR 190, the Environmental Protection Agency's Environmental Radiation Protection Standards for Nuclear Power Operations, specify that the annual dose equivalent must not exceed 25 mrems to the whole body, 75 mrems to the thyroid, and 25 mrems to any other organ of any member of the public as the result of exposures to planned discharges of radioactive materials (radon and its daughters excepted) to the general environment from all uranium-fuel-cycle operations and radiation from these operations that can be expected to affect a given individual. The staff's position as stated in NUREG-0543 is, as long as a nuclear plant site operates at a level below the relatively more conservative Appendix I dose design objectives and reporting requirements, it is operating in compliance with 40 CFR Part 190. Therefore, the NRC staff concludes that under normal operations the Limerick facility is capable of operating within these EPA standards.

The radiological doses and dose commitments resulting from a nuclear power plant are well known and documented. Accurate measurements of radiation and radioactive contaminants can be made with very high sensitivity so that much smaller amounts of radioisotopes can be recorded than can be associated with any possible observable ill effects. Furthermore, the effects of radiation on living systems have for decades been subject to intensive investigation and consideration by individual scientists as well as by select committees that have occasionally been constituted to objectively and independently assess radiation dose effects. Although, as in the case of chemical contaminants, there is debate about the exact extent of the effects of very low levels of radiation that result from nuclear-power-plant effluents, upper bound limits of deleterious effects are well established and amenable to standard methods of risk analysis. Thus the risks to the maximally exposed member of the public outside of the site boundaries or to the total population outside of the boundaries can be readily calculated and recorded. These risk estimates for the Limerick facility are presented below.

The risk to the maximally exposed individual is estimated by multiplying the risk estimators presented in Section 5.9.3.1.1 by the annual dose-design objectives for total-body radiation in 10 CFR 50, Appendix I. This calculation results in a risk of potential premature death from cancer to that individual from exposure to radioactive effluents (gaseous or liquid) from 1 year of reactor operations of less than one chance in one million.* The risk of potential premature death from cancer to the average individual within 80 km (50 miles) of the reactors from exposure to radioactive effluents from the reactors is much less than the risk to the maximally exposed individual. These risks are very small in comparison to natural cancer incidence from causes unrelated to the operation of the Limerick facility.

Multiplying the annual U.S. general public population dose from exposure to radioactive effluents and transportation of fuel and waste from the operation of this facility (that is, 83 person-rems) by the preceding somatic risk estimator, the staff estimates that about 0.01 cancer death may occur in the exposed population. The significance of this risk can be determined by comparing it to the natural incidence of cancer deaths in the U.S. population. Multiplying the estimated U.S. population for the year 2000 (~260 million persons) by the current incidence of actual cancer fatalities (~20%), about 52 million cancer deaths are expected (American Cancer Society, 1982). For purposes of evaluating the potential genetic risks, the progeny of workers are considered members of the general public. Multiplying the sum of the U.S. population dose from exposure to radioactivity attributable to the normal annual operation of the plant (that is, 82 person-rems), and the estimated dose from occupational exposure (that is, 1254 person-rems) by the preceding genetic risk estimators, the staff estimates that about 0.3 potential genetic disorder may occur in all future generations of the exposed population. Because BEIR III indicates that the mean persistence of the two major types of genetic disorders is about 5 generations and 10 generations, in the following analysis the risk of potential genetic disorders from the normal annual operation of the plant is conservatively compared with the risk of actual genetic ill health in the first 5 generations rather than the first 10 generations. Multiplying the estimated population within 80 km (50 miles) of the plant (~8,100,000 persons in the year 2000) by the current incidence of actual genetic ill health in each generation (~11%), about 890,000 genetic abnormalities are expected in the first 5 generations of the 80-km population (BEIR III).

The risks to the general public from exposure to radioactive effluents and transportation of fuel and wastes from the annual operation of the Limerick facility are very small fractions of the estimated normal incidence of cancer fatalities and genetic abnormalities in the year 2000 population. On the basis of the preceeding comparison, the NRC staff concludes that the risk to the public health and safety from exposure to radioactivity associated with the normal operation of the Limerick facility will be very small.

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*The risk of potential premature death from cancer to the maximally exposed individual from exposure to radioiodines and particulates would be in the same range as the risk from exposure to the other types of effluents.

5.9.3.3 Radiological Impacts on Biota Other than Humans

Depending on the pathway and the radiation source, terrestrial and aquatic biota will receive doses that are approximately the same or somewhat higher than humans receive. Although guidelines have not been established for acceptable limits for radiation exposure to species other than humans, it is generally agreed that the limits established for humans are sufficiently protective for other species.

Although the existence of extremely radiosensitive biota is possible and increased radiosensitivity in organisms may result from environmental interactions with other stresses (for example, heat or biocides), no biota have yet been discovered that show a sensitivity (in terms of increased morbidity or mortality) to radiation exposures as low as those expected in the area surrounding the facility. Furthermore, at all nuclear plants for which radiation exposure to biota other than humans has been analyzed (Blaylock, 1976), there have been no cases of exposure that can be considered significant in terms of harm to the species, or that approach the limits for exposure to members of the public that are permitted by 10 CFR 20. Inasmuch as the 1972 BEIR Report (BEIR I) concluded that evidence to date indicated that no other living organisms are very much more radiosensitive than humans, no measurable radiological impact on populations of biota is expected as a result of the routine operation of this facility.

5.9.3.4 Radiological Monitoring

Radiological environmental monitoring programs are established to provide data where there are measurable levels of radiation and radioactive materials in the site environs and to show that in many cases no detectable levels exist. Such monitoring programs are conducted to verify the effectiveness of inplant systems used to control the release of radioactive materials and to ensure that unanticipated buildups of radioactivity will not occur in the environment. Secondarily, the environmental monitoring programs could identify the highly unlikely existence of releases of radioactivity from unanticipated release points that are not monitored. An annual surveillance (land census) program will be established to identify changes in the use of unrestricted areas to provide a basis for modifications of the monitoring programs or of the Technical Specification conditions that relate to the control of doses to individuals.

These programs are discussed generically in greater detail in RG 4.1, Revision 1, "Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants," and the Radiological Assessment Branch Technical Position, Revision 1, November 1979, "An Acceptable Radiological Environmental Monitoring Program."*

5.9.3.4.1 Preoperational

The preoperational phase of the monitoring program should provide for the measurement of background levels of radioactivity and radiation and their variations along the anticipated important pathways in the areas surrounding the facility, the training of personnel, and the evaluation of procedures, equipment, and techniques. The applicant proposed a radiological environmental-monitoring program to meet these objectives in the ER-CP, and it was discussed

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*Available from the Radiological Assessment Branch, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, Washington, DC 20555.

in the FES-CP. This early program has been updated and expanded; it is presented in Section 6.1.5 of the applicant's ER-OL and is summarized here in Tables 5.8 through 5.11.

The applicant states that the preoperational program will have been implemented at least 2 years before initial criticality of Unit 1 to document background levels of direct radiation and concentrations of radionuclides that exist in the environment. The preoperational program will continue up to initial criticality of Unit 1, at which time the operational radiological monitoring program will commence.

The staff has reviewed the preoperational environmental monitoring plan of the applicant and finds that it is acceptable as presented. The current NRC staff position is that a total of about 40 dosimetry stations (or continuously recording dose-rate instruments) should be placed as follows: an inner ring of stations in the general area of the site boundary and an outer ring in the 6 to 8 km (4 to 5 mile) range from the site with a station in each sector of each ring (16 sectors x 2 rings = 32 stations). The remaining eight stations should be placed in special interest areas such as population centers, nearby residences and schools, and in two or three areas to serve as control stations. The station locations have been reviewed by the NRC staff and are specified in Table 5.9.

5.9.3.4.2 Operational

The operational offsite radiological-monitoring program is conducted to provide data on measurable levels of radiation and radioactive materials in the site environs in accordance with 10 CFR 20 and 50. It assists and provides backup support to the effluent-monitoring program recommended in RG 1.21, "Measuring, Evaluating and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water Cooled Nuclear Power Plants."

The applicant states that the operational program will in essence be a continuation of the preoperational program described above, with some periodic adjustment of sampling frequencies in expected critical exposure pathways--such as increasing milk sampling frequency and deletion of fruit, vegetable, soil, and gamma radiation survey samples. The proposed operational program will be reviewed prior to plant operation. Modification will be based upon anomalies and/or exposure pathway variations observed during the preoperational program.

The final operational-monitoring program proposed by the applicant will be reviewed in detail by the NRC staff, and the specifics of the required monitoring program will be incorporated into the operating license Radiological Technical Specifications.

5.9.4 Environmental Impacts of Postulated Accidents

5.9.4.1 Plant Accidents

The staff has considered the potential radiological impacts on the environment of possible accidents at the Limerick Generating Station, Units 1 and 2, in accordance with a Statement of Interim Policy published by the Nuclear Regulatory Commission on June 13, 1980 (45 FR 40101-40104). The following discussion reflects the staff's considerations and conclusions.

Table 5.8 Preoperational radiological environmental monitoring program summary

Year	Sample type	No. of stations	Analysis	Frequency of analysis
1982 (partial)	Direct radiation	48	Gamma dose	Monthly
	Air (particulate & iodine)	17	Radioiodine (I-131)	---
			Gross beta	Weekly
			Gamma isotopic composite	Monthly
	Surface water	5	Gamma isotopic	Monthly
			Tritium composite	Quarterly
			Gross beta (soluble & insoluble)	Monthly
	Drinking water	5	Gamma isotopic	Monthly
			Tritium composite	Quarterly
			Gross beta (soluble & insoluble)	Monthly
	Groundwater	2	Gamma isotopic	Semi-annually
			Tritium	Semi-annually
	Sediment	3	Gamma isotopic	Semi-annually
	Fish	3	Gamma isotopic	Semi-annually
	Vegetation	1	Radioiodine	Monthly when available
	Milk	12	Radioiodine (I-131)	Quarterly
			Gamma isotopic	Quarterly
	Small game	1	Gamma isotopic	Annually
1983 (partial)	Direct radiation	48	Gamma dose	Monthly
	Air (particulate & iodine)	17	Gross beta	Weekly
			Gamma isotopic composite	Monthly

Table 5.8 (continued)

Year	Sample type	No. of stations	Analysis	Frequency of analysis
1983	Surface water	5	Gamma isotopic	Monthly
			Tritium composite	Quarterly
			Gross beta (soluble & insoluble)	Monthly
	Drinking water	5	Gamma isotopic	Monthly
			Tritium composite	Quarterly
			Gross beta (soluble & insolube)	Monthly
	Groundwater	2	Gamma isotopic	Semi-annually
			Tritium	Semi-annually
	Sediment	3	Gamma isotopic	Semi-annually
	Fish	3	Gamma isotopic	Semi-annually
	Vegetation	1	Radioiodine	Monthly during growing season
	Milk	12	Radioiodine (I-131)	Quarterly
	Small game	1	Gamma isotopic	Annually
1984	Direct radiation	48	Gamma dose	Monthly
	Air (particulate & iodine)	17	Radioiodine (I-131)	Weekly (7 stations)
			Gross beta	Weekly
			Gamma isotopic composite	Monthly

Table 5.8 (continued)

Year	Sample type	No. of stations	Analysis	Frequency of analysis
1984	Surface water	5	Gamma isotopic	Monthly
			Tritium composite	Quarterly
			Gross beta (soluble & insoluble)	Monthly
	Drinking water	5	Gamma isotopic	Monthly
			Tritium composite	Quarterly
			Gross beta (soluble & insoluble)	Monthly
	Groundwater	2	Gamma isotopic	Semi-annually
			Tritium	Semi-annually
	Sediment	3	Gamma isotopic	Semi-annually
	Fish	3	Gamma isotopic	Semi-annually
	Vegetation	1	Radioiodine	Monthly during growing season
	Milk	13	Radioiodine (I-131)	Bi-weekly during grazing season, monthly at other times (4 stations)
				Monthly analysis only (9 stations)
			Gamma isotopic	Quarterly
	Small Game	1	Gamma isotopic	Annually

Source: ER-OL Table 6.1-45, through Revision 17, February 1984

Table 5.9 Preoperational radiological environmental monitoring program station locations

Location description	Code	Sector	Distance (km)
<u>TLD (inner ring)</u>			
Evergreen & Sanatoga Rd., N sector site boundary	36S1	N	0.97
Sanatoga Rd., NNE sector site boundary	3S1	NNE	0.97
Possum Hollow Rd.	5S1	NE	0.64
Limerick Training Center	7S1	ENE	0.80
Keen Rd.	10S1	E	0.80
Limerick Information Center	11S1	ESE	0.80
Longview Rd., SE sector site boundary	14S1	SE	0.97
Longview Rd., SSE sector site boundary	16S2	SSE	0.97
Railroad tracks along Longview Rd.	18S1	S	0.48
Impounding basin, SSW sector site boundary	21S1	SSW	0.80
Transmission tower, SW sector site boundary	23S2	SW	0.80
WSW sector site boundary	25S1	WSW	0.80
Met tower 2 site	26S3	W	0.64
WNW sector site boundary	29S1	WNW	0.80
NW sector site boundary	32S1	NW	0.97
Met tower 1 site	34S2	NNW	0.97
<u>TLD (outer ring)</u>			
Ringing Rock substation	35F1	N	6.8
Laughing Waters GSC	2E1	NNE	8.2
Neiffer Rd.	4E1	NE	7.4
Pheasant Rd. Game Farm site	7E1	ENE	6.8
Transmission corrider, Royersford Rd.	10E1	E	6.3
Trappe substation	10F3	ESE	8.8
Vaughn substation	13E1	SE	6.9
Pikeland substation	16F1	SSE	7.9

Table 5.9 (continued)

Location description	Code	Sector	Distance (km)
Snowden substation	19D1	S	5.8
Sheeder substation	20F1	SSW	8.4
Porters Mill substation	24D1	SW	6.3
Transmission corrider, Hoffecker & Keim Sts.	25D1	WSW	6.4
Transmission corrider, W. Cedarville Rd.	28D2	W	6.1
Prince St.	29E1	WNW	7.9
Poplar substation	31D2	NW	6.3
Yarnell Rd.	34E1	NNW	7.4
<u>TLD (control stations and other selected locations)</u>			
Sanatoga substation	2B1	NNE	2.4
Birch substation	5H1	NE	42
Pottstown landing field	6C1	ENE	3.4
Reed Rd.	9C1	E	3.5
King Rd.	13C1	SE	4.7
3508 Market St., Philadelphia	13H3	SE	45
Spring City substation	15D1	SE	5.1
Linfield substation	17B1	S	2.6
Planebrook substation	18G1	S	21
Ellis Woods Rd.	20D1	SSW	5
Manor substation	22G1	SW	28
Old Schuylkill Rd.	26B1	W	2.7
Yost Rd.	29B1	WNW	2.9
Lincoln substation	31D1	NW	4.8
Friedensburg substation	32G1	NW	25
Pleasantview Rd.	35B1	NNW	3.1
<u>Dairy farms</u>			
	5C1	NE	4.2
	9E1	E	6.6
	9G1	E	18
	10B1	ESE	1.8
	10C1	ESE	4.5

Table 5.9 (continued)

Location description	Code	Sector	Distance (km)
	11E1	ESE	7.9
	17C2	S	4.0
	17D1	S	5.8
	18C1	S	3.1
	21B1	SW	2.7
	22F1	SW	16
	25B1	WSW	2.1
	36E1	N	7.6
<u>Air particulate and iodine</u>			
Sanatoga substation	2B1	NNE	2.4
Pottstown landing field	6C1	ENE	3.4
Reed Rd.	9C1	E	3.5
Keen Rd.	10S3	E	0.80
Limerick Information Center	11S1	ESE	0.80
King Rd.	13C1	SE	4.7
2301 Market St., Philadelphia	13H4	SE	46
Longview Rd., SE sector site boundary	14S1	SE	0.97
Spring City substation	15D1	SE	5.1
Linfield substation	17B1	S	2.6
Ellis Woods Rd.	20D1	SSW	5
Manor substation	22G1	SW	28
Old Schuylkill Rd.	26B1	W	2.7
Yost Rd.	29B1	WNW	2.9
Lincoln substation	31D1	NW	4.8
Met tower 1	34S2	NNW	0.97
Pleasantview Rd.	35B1	NNW	3.1
<u>Vegetation</u>			
Limerick Information Center garden	11S1	ESE	0.80
<u>Fish</u>			
Upstream of Limerick (Keim St. bridge to Hanover St. bridge)	29C1*		

Table 5.9 (continued)

Location description	Code	Sector	Distance (km)
Downstream of Limerick discharge	20S1*		
Middle of Vincent pool upstream to Pigeon Creek	16C5*		
<u>Game</u>			
Fricks Lock, Limerick vicinity	26S5*		
<u>Sediment</u>			
Upriver from Limerick discharge	33A2*		
Linfield bridge area	16B2*		
Vincent Dam pool area	16C4*		
<u>Water sampling stations</u>			
Surface water:			
Limerick intake	24S1*		
Fricks Lock boat house	24S2*		
Linfield bridge	16B2*		
Philadelphia Suburban Water Company	15F5*		
Perkiomen pumping station	10F2*		
<u>Drinking water</u>			
Philadelphia Suburban Water Company	15F4*		
Phoenixville Water Works	15F7*		
Citizens Home Water Company	16C2*		
Pottstown Water Authority	28F3*		
Belmont Water Works (Philadelphia)	13H2*		
<u>Well Water</u>			
Limerick Information Center	11S1*		
<u>Well Water</u>			
S sector farm near site	18A1*		

*See ER-OL Figures 6.1-23 through 6.1-29 for details.

Source: ER-OL Table 6.1-46, through Revision 17, February 1984

Table 5.10 Detection capabilities for environmental sample analyses

Sample type	Analysis	Sensitivity LLD*	Nonroutine reporting levels	Units
Surface water	Gross beta (insol)	4	200	pCi/l
	Gross beta (sol)	4	200	
	Tritium	2000	20000	
	Gamma			
	Mn-54	15	1000	
	Fe-59	30	400	
	Co-58	15	1000	
	Co-60	15	300	
	Zn-65	30	300	
	Zr-95	30	400	
	Nb-95	15	400	
	Cs-134	15	30	
	Cs-137	18	50	
	Ba-140	60	200	
	La-140	15	200	
Drinking water	Gross beta (insol)	4	200	pCi/l
	Gross beta (sol)	4	200	
	Tritium	2000	20000	
	Gamma			
	Mn-54	15	1000	
	Fe-59	30	400	
	Co-58	15	1000	
	Co-60	15	300	
	Zn-65	30	300	
	Zr-95	30	400	
	Nb-95	15	400	
	Cs-134	15	30	
	Cs-137	18	50	
	Ba-140	60	200	
	La-140	15	200	
Well water	Tritium	2000	20000	pCi/l
	Gamma			
	Mn-54	15	1000	
	Fe-59	30	400	
	Co-58	15	1000	
	Co-60	15	300	
	Zn-65	30	300	
	Zr-95	30	400	
	Nb-95	15	400	
	Cs-134	15	30	
	Cs-137	18	50	
	Ba-140	60	200	

Table 5.10 (continued)

Sample type	Analysis	Sensitivity LLD*	Nonroutine reporting levels	Units
Milk	I-131	1	3	pCi/l
	Gamma			
	Cs-134	15	60	
	Cs-137	18	70	
	Ba-140	60	300	
	La-140	15	300	
Food products	Gamma			
	I-131	0.06	0.1	pCi/g(wet)
	Cs-134	0.06	1.0	
	Cs-137	0.08	2.0	
Game	Gamma			
	Cs-134	0.06		pCi/g(wet)
	Cs-137	0.08		
Fish	Gamma			
	Mn-54	0.130	30	pCi/g(wet)
	Fe-59	0.260	10	
	Co-58	0.130	30	
	Co-60	0.130	10	
	Zn-65	0.260	20	
	Cs-134	0.130	1	
	Cs-137	0.150	2	
Sediment	Gamma			
	Cs-134	0.150		pCi/g(dry)
	Cs-137	0.180		
Air particulates	Gross beta	0.01		pCi/m^3
	Gamma			
	Cs-134	0.05	10	
	Cs-137	0.06	20	
Air iodine	I-131	0.07	0.9	pCi/m^3
Direct radiation	TLD	RG 4.15		mrad/std month

*LLD is the "a priori" lower limit of detection, defined as the smallest concentration of radioactive material in a sample (picocuries per unit of mass or volume) that will yield a net count, above system background, that will be detected with 95% probability, with only 5% probability of falsely concluding that a blank observation represents a "real" signal.

Source: ER-OL Table 6.1-47, through Revision 17, February 1984

Table 5.11 Environmental sampling and measuring equipment

Sample type of measurement	Equipment
Airborne particulate & radioiodine	Continuous air pump that passes approximately 1 cfm through filter paper and charcoal cartridge
Surface water (composite)	Automatic composite sampler
Drinking water (composite)	Automatic composite sampler
Direct radiation	Thermoluminescent dosimeter
Fish	Trap net, seine, hook and line, electro fishing apparatus and/or equivalent equipment

Source: ER-OL Table 6.1-48, Revision 17, February 1984

Section 5.9.4.2 deals with general characteristics of nuclear power plant accidents, including a brief summary of safety measures provided to minimize the probability of their occurrence and to mitigate their consequences if they should occur. Also described are the important properties of radioactive materials and the pathways by which they could be transported to become environmental hazards. Potential adverse health effects and impacts on society associated with actions to avoid such health effects also are identified.

Next, actual experience with nuclear power plant accidents and their observed health effects and other societal impacts are described. This is followed by a summary review of safety features of the Limerick station and of the site that act to mitigate the consequences of accidents.

The results of calculations of the potential consequences of accidents that have been postulated in the design basis are then given. Also described are the results of calculations for the Limerick site using contemporary probabilistic methods and their inherent uncertainties to estimate the possible impacts and the risks associated with severe accident sequences of low probability of occurrence.

5.9.4.2 General Characteristics of Accidents

The term "accident," as used in this section, refers to any unintentional event not addressed in Section 5.9.3 that results in a release of radioactive materials into the environment. The predominant focus, therefore, is on events that can lead to releases substantially in excess of permissible limits for normal operation. Normal release limits are specified in the Commission's regulations at 10 CFR 20, and 10 CFR 50, Appendix I.

There are several features that combine to reduce the risk associated with accidents at nuclear power plants. Safety features provided for in design, construction, and operation comprise the first line of defense and are to a very large extent devoted to the prevention of the release of radioactive materials from their normal places of confinement within the plant. There are also a number of additional lines of defense that are designed to mitigate the consequences of failures in the first line. These safety features are designed taking into consideration the specific locations of radioactive materials within the plant; their amounts; their nuclear, physical, and chemical properties; and their relative tendency to be transported into and for creating biological hazards in the environment. Descriptions of these features for Limerick Units 1 and 2 may be found in the applicant's FSAR and in the staff's Safety Evaluation Report (SER, NUREG-0991). The most important mitigative features are described in Section 5.9.4.4(1) below.

(1) <u>Fission Product Characteristics</u>

By far the largest inventory of radioactive material in a nuclear power plant is produced as a byproduct of the fission process and is located in the uranium oxide fuel pellets in the reactor core in the form of fission products. During periodic refueling shutdowns, the assemblies containing these fuel pellets are transferred to a spent-fuel storage pool so that the second largest inventory of radioactive material is located in this storage area. Much smaller inventories of radioactive materials also are normally present in the water that circulates in the reactor coolant system and in the systems used to process gaseous and liquid radioactive wastes in the plant.

All these radioactive materials exist in a variety of physical and chemical forms. Their potential for dispersion into the environment depends not only on mechanical forces that might physically transport them, but also upon their inherent properties, particularly their volatility. The majority of these materials exist as nonvolatile solids over a wide range of temperatures. Some, however, are relatively volatile solids and a few are gaseous in nature. Such characteristics have a significant bearing upon the assessment of the environmental radiological impact of accidents.

The gaseous materials include radioactive forms of the chemically inert noble gases krypton and xenon. These have the highest potential for release into the atmosphere. If a reactor accident were to occur involving degradation of the fuel cladding, the release of substantial quantities of these radioactive gases from the fuel is a virtual certainty. Such accidents are of low frequency, but are considered credible events (see Section 5.9.4.3). It is for this reason that the safety analysis of each nuclear power plant incorporates a hypothetical design-basis accident that postulates the release of the entire contained inventory of radioactive noble gases from the fuel in the reactor vessel into the containment structure. If these gases were further released to the environment as a possible result of failure of safety features, the hazard to individuals from these noble gases would arise predominantly through the external gamma radiation from the airborne plume. The reactor containment structure and other features are designed to minimize this type of release.

Radioactive forms of iodine are formed in substantial quantities in the fuel by the fission process and in some chemical forms may be quite volatile. For these reasons, they have traditionally been regarded as having a relatively high potential for release (1) from the fuel at higher than normal temperatures, or (2) from defects in fuel pins. If radioiodines are released to the environment, the principal radiological hazard associated with the radioiodines is incorporation into the human body and subsequent concentration in the thyroid gland. Because of this, the potential for release of radioiodines to the atmosphere is reduced by the use of special structures, components, and systems designed to retain the iodine. The chemical forms in which the fission product radioiodines are found are generally solid materials at room temperatures, so they have a strong tendency to condense (or "plate out") upon cooler surfaces. In addition, most of the iodine compounds are quite soluble in or chemically reactive with water. Although these properties do not inhibit the release of radioiodines from degraded fuel, they do act to mitigate the release both to and from containment structures that have large internal surface areas and that contain large quantities of water as a result of an accident. The same properties affect the behavior of radioiodines that may "escape" into the atmosphere. Thus, if rainfall occurs during a release, or if there is moisture on exposed surfaces (for example, dew), the radioiodines will show a strong tendency to be absorbed by the moisture. Although less volatile than many iodine compounds, virtually all cesium and rubidium (alkali metals) compounds are soluble in or react strongly with water, and would behave similarly in the presence of moisture. In addition, the more volatile iodine compounds are capable of reacting with vegetation and traces of organic gases and pollen normally present in air, while many alkali metal compounds are capable of reacting with siliceous materials such as concrete, glass and soil.

Other radioactive materials formed during the operation of a nuclear power plant have lower volatilities and by comparison with the noble gases, iodine and alkali metals have a much smaller tendency to escape from degraded fuel unless the temperature of the fuel becomes very high. By the same token, if such materials escape by volatilization from the fuel, they tend (1) to condense quite rapidly to solid form again when they are transported to a region of lower temperature and/or (2) to dissolve in water when it is present. The former mechanism can have the result of producing some solid particles of sufficiently small size to be carried some distance by a moving stream of gas or air. If such particulate materials are dispersed into the atmosphere as a result of failure of the containment barrier, they will tend to be carried downwind and deposit on surfaces by gravitational settling or by precipitation (fallout), where they will become "contamination" hazards in the environment.

All of these radioactive materials exhibit the property of radioactive decay with characteristic half-lives ranging from fractions of a second to many days or years (see Table 5.11a). Many of them decay through a sequence or chain of decay processes, and all eventually become stable (nonradioactive) materials. The radiation emitted during these decay processes is the reason that they are hazardous materials. As a result of radioactive decay, most fission product elements transmute into other elements. Iodines transmute into noble gases, for example, while the noble gases transmute into alkali metals. Because of this property, fission products which escape into the environment as one element may later become a contamination hazard as a different element.

(2) Exposure Pathways

The radiation exposure (hazard) to individuals is determined by their proximity to the radioactive materials, the duration of exposure, and factors that act to

Table 5.11a Activity of radionuclides in a Limerick reactor core at 3458 MWt (WASH-1400 basis)

Group/radionuclide	Radioactive inventory (millions of Ci)	Half-life (days)
A. NOBLE GASES		
Krypton-85	0.6	3,950
Krypton-85m	30	0.183
Krypton-87	50	0.0528
Krypton-88	70	0.117
Xenon-133	200	5.28
Xenon-135	40	0.384
B. IODINES		
Iodine-131	90	8.05
Iodine-132	100	0.0958
Iodine-133	200	0.875
Iodine-134	200	0.0366
Iodine-135	200	0.280
C. ALKALI METALS		
Rubidium-86	0.03	18.7
Cesium-134	8	750
Cesium-136	3	13.0
Cesium-137	5	11,000
D. TELLURIUM-ANTIMONY		
Tellurium-127	6	0.391
Tellurium-127m	1	109
Tellurim-129	30	0.048
Tellurim-129m	6	34.0
Tellurium-131m	10	1.25
Tellurium-132	100	3.25
Antimony-127	7	3.88
Antimony-129	40	0.179
E. ALKALINE EARTHS		
Strontium-89	100	52.1
Strontium-90	4	11,030
Strontium-91	100	0.403
Barium-140	200	12.8
F. COBALT AND NOBLE METALS		
Cobalt-58	0.8	71.0
Cobalt-60	0.3	1,920
Molybdenum-99	200	2.8
Technetium-99m	200	0.25

Table 5.11a (Continued)

Group/radionuclide	Radioactive inventory (millions of Ci)	Half-life (days)
F. COBALT AND NOBLE METALS (Continued)		
Ruthenium-103	100	39.5
Ruthenium-105	100	0.185
Ruthenium-106	30	366
Rhodium-105	50	1.50
G. RARE EARTHS, REFRACTORY OXIDES AND TRANSURANICS		
Yttrium-90	4	2.67
Yttrium-91	100	59.0
Zirconium-95	200	65.2
Zirconium-97	200	0.71
Niobium-95	200	35.0
Lanthanum-140	200	1.67
Cerium-141	200	32.3
Cerium-143	100	1.38
Cerium-144	100	284
Praseodymium-143	100	13.7
Neodymium-147	60	11.1
Neptunium-239	2000	2.35
Plutonium-238	0.06	32,500
Plutonium-239	0.02	8.9×10^6
Plutonium-240	0.02	2.4×10^6
Plutonium-241	4	5,350
Americium-241	0.002	1.5×10^5
Curium-242	0.5	163
Curium-244	0.03	6,630

Note: The above grouping of radionuclides corresponds to that in Table 5.11c. The listed inventory has been rounded to one significant digit to reflect its accuracy in describing the Limerick core. All calculations, however, were done using the CRAC data file at much higher precision.

shield the individual from the radiation. Pathways that lead to radiation exposure hazards to humans are generally the same for accidental as for "normal" releases. These are depicted in Figure 5.4. There are two additional possible pathways that could be significant for accident releases that are not shown in Figure 5.4. One of these is the fallout onto open bodies of water of radioactivity initially carried in the air. The second would be unique to an accident that results in temperatures inside the reactor core sufficiently high to cause uncontrolled or unmitigated melting and subsequent penetration of the basemat underlying the reactor by the molten core debris. This situation could create the potential for the release of radioactive material into the hydrosphere through contact with groundwater, and may lead to external exposure to radiation and to internal exposures if radioactive material is inhaled or ingested from contaminated food or water.

It is characteristic of the transport of radioactive material by wind or by water that the material tends to spread and disperse, like a plume of smoke from a smokestack, becoming less concentrated in larger volumes of air or water. The results of these natural processes are to lessen the intensity of exposure to individuals downwind or downstream of the point of release, but to increase the number who may be exposed. The bulk of radioactive releases is more likely to reach the atmosphere than to reach streams or groundwater. For a release into the atmosphere, the degree to which dispersion reduces the concentration in the plume at any downwind point is governed by the turbulence characteristics of the atmosphere, which vary considerably with time and from place to place. This fact, taken in conjunction with the variability of wind direction and the presence or absence of precipitation, means that accident consequences are very much dependent upon the weather conditions existing at the time of the accident.

(3) Health Effects

The cause-and-effect relationships between radiation exposure and adverse health effects are quite complex (National Research Council, 1979; Land, 1980), but they have been studied exhaustively in comparison to many other environmental contaminants.

Whole-body radiation exposure resulting in a dose greater than about 10 rems for a few persons and about 25 rems for nearly all people over a short period of time (hours) is necessary before any physiological effects to an individual are clinically detectable. Doses about 7 or more times larger than the latter dose also received over a relatively short period of time (hours to a few days), can be expected to cause some fatal injuries. At the severe but extremely low probability end of the accident spectrum, exposures of these magnitudes are theoretically possible for persons in close proximity to such accidents if measures are not or cannot be taken to provide protection, such as sheltering or evacuation.

Lower levels of exposures also may constitute a health risk, but the ability to define a direct cause-and-effect relationship between any given health effect and a known exposure to radiation is difficult, given the backdrop of the many other possible reasons why a particular effect is observed in a specific individual. For this reason, it is necesary to assess such effects on a statistical basis. Such effects include randomly occurring cancer in the exposed population and genetic changes in future generations after exposure of a prospective parent. The occurrence of cancer itself is not necessarily indicative of fatality, however. Occurrences of cancer in the exposed population may begin to develop only after a lapse of 1 to 15 years (latent period) from the time of exposure and then continue over a period of about 30 years (plateau period). However, in the case of exposure to fetuses (in utero), occurrences of cancer may begin to develop at birth (no latent period) and end at age 10 (that is, the plateau period is 10 years). The health consequences model used was based on the 1972 BEIR I Report of the National Academy of Sciences (NAS, 1972).

Most authorities agree that a reasonable, and probably conservative, estimate of the randomly occurring number of health effects of low levels of radiation exposure to a large number of people is within the range of about 10 to 500 potential cancer deaths per million person-rems (although zero is not excluded by the data). The range comes from the latest NAS BEIR III Report (1980), which also indicates a probable value of about 150. This value is virtually identical to the value of about 140 used in the NRC health-effects models. In addition, approximately 220 genetic changes per million person-rems would be projected over succeeding generations by models suggested in the BEIR III report. This also compares well with the value of about 260 per million person-rems used by the NRC staff, which was computed as the sum of the risk of specific genetic defects and the risk of defects with complex etiology.

(4) Health Effects Avoidance

Radiation hazards in the environment tend to disappear by the natural processes of radioactive decay and weathering. However, where the decay process is slow, and where the material becomes relatively fixed in its location as an environmental contaminant (such as in soil), the hazard can continue to exist for a relatively long period of time--months, years, or even decades. Thus, a possible consequential environmental societal impact of severe accidents is the avoidance of the health hazard rather than the health hazard itself, by restrictions on the use of the contaminated property or contaminated foodstuffs, milk, and drinking water. The potential economic impacts that this avoidance can cause are discussed below.

5.9.4.3 Accident Experience and Observed Impacts

As of February 1983, there were 76 commercial nuclear power reactor units licensed for operation in the United States at 52 sites, with power-generating capacities ranging from 50 to 1180 megawatt electric (MWe). (Limerick Units 1 and 2 are designed for 1055 MWe per unit). The combined experience with all these units represents approximately 500 reactor years of operation over an elapsed time of about 20 years. Accidents have occurred at several of these facilities (Oak Ridge National Laboratory, 1980; NUREG-0651). Some of these have resulted in releases of radioactive material to the environment ranging from very small fractions of a curie to a few million curies. None is known to have caused any radiation injury or fatality to any specific member of the public, nor any significant individual or collective public radiation exposure, nor any significant contamination of the environment. This experience base is not large enough to permit a reliable quantitative statistical inference for predicting accident probabilities. It does, however, suggest that significant environmental impacts caused by accidents are very unlikely to occur over time periods of a few decades.

Melting or severe degradation of reactor fuel has occurred in only one of these units, during the accident at Three Mile Island Unit 2 (TMI-2) on March 28, 1979. In addition to the release to the environment of a few million curies of noble gases, mostly xenon-133, it has been estimated that approximately 15 curies of radioiodine also were released to the environment at TMI-2 (NRC Special Inquiry Group, 1980). This amount represents an extremely minute fraction of the total radioiodine inventory present in the reactor at the time of the accident. No other radioactive fission products were released to the environment in measurable quantity. It has been estimated that the maximum cumulative offsite radiation dose to an individual was less then 100 mrems (NRC Special Inquiry Group, 1980; President's Commission on the Accident at Three

Mile Island, 1979). The total population exposure has been estimated to be in the range from about 1000 to 5300 person-rems. This exposure could produce between none and one additional fatal cancer over the lifetime of the population. The same population receives each year from natural background radiation about 240,000 person-rems. Approximately a half-million cancers are expected to develop in this group over their lifetimes (NRC Special Inquiry Group, 1980; President's Commission on the Accident at Three Mile Island, 1979), primarily from causes other than radiation. Trace quantities (barely above the limit of detectability) of radioiodine were found in a few samples of milk produced in the area. No other food or water supplies were impacted.

Accidents at nuclear power plants also have caused occupational injuries and a few fatalities, but none attributed to radiation exposure. Individual worker exposures have ranged up to about 5 rems as a direct consequence of reactor accidents (although there have been higher exposures to individual workers as a result of other unusual occurrences). However, the collective worker exposure levels (person-rem) are a small fraction of the exposures experienced during normal routine operations that average about 440 to 1300 preson-rems in a PWR and 790 to 1660 person-rems in a BWR per reactor-year.

Accidents also have occurred at other nuclear reactor facilities in the United States and in other countries (Oak Ridge National Laboratory, 1980; NUREG-0651). Because of inherent differences in design, construction, operation, and purpose of most of these other facilities, their accident record has only indirect relevance to current nuclear power plants. Melting of reactor fuel occurred in at least seven of these accidents, including the one in 1966 at the Enrico Fermi Atomic Power Plant, Unit 1. Fermi Unit 1 was a sodium-cooled fast breeder demonstration reactor designed to generate 61 MWe. This accident did not release any radioactivity to the environment. The damages were repaired and the reactor reached full power 4 years following the accident. It operated successfully and completed its mission in 1973.

A reactor accident in 1957 at Windscale, England, released a significant quantity of radioiodine, approximately 20,000 curies, to the environment (United Kingdom Atomic Energy Office, "Accident at Windscale," 1957). This reactor, which was not operated to generate electricity, used air rather than water to cool the uranium fuel. During a special operation to heat the large amount of graphite in this reactor (characteristic of a graphite-moderated reactor), the fuel overheated and radioiodine and noble gases were released directly to the atmosphere from a 123-m (405-foot) stack. Milk produced in a 518-km^2 (200-mi^2) area around the facility was impounded for up to 44 days. The United Kingdom National Radiological Protection Board estimated that the releases may have caused about 260 cases of thyroid cancer, about 13 of them fatal, and about 7 deaths from other cancers or hereditary diseases (NRPB-R135, Crick and Linsley, 1982). This kind of accident cannot occur in a water moderated- and -cooled reactor like Limerick, however.

5.9.4.4 Mitigation of Accident Consequences

Pursuant to the Atomic Energy Act of 1954, the NRC conducted a safety evaluation of the application to operate Limerick Units 1 and 2 (NUREG-0991). Although NUREG-0991 contains more detailed information on plant design, the principal design features are addressed in the following section.

(1) Design Features

Limerick Units 1 and 2 are essentially identical. Each unit contains features designed to prevent accidental release of fission products from the fuel and to lessen the consequences should such a release occur. These accident-preventive and mitigative features are referred to collectively as engineered safety features (ESF). To establish design and operating specifications for ESF, postulated events referred to as design-basis accidents are analyzed.

An emergency core cooling system (ECCS) is provided to supply cooling water to the reactor core during an accident to prevent or minimize fuel damage. Means of removing heat energy from the containment to mitigate its overpressurization following an accident are also provided.

The containment system itself is a passive ESF, designed to prevent direct escape of released fission products to the environment. The Limerick containment structures consist of an inner primary containment and an outer secondary containment. The primary containment is designed to withstand internal pressures resulting from reactor accidents. The secondary containment surrounds the primary containment and includes all equipment outside primary containment that could handle fission products in the event of an accident. The secondary containment is designed to collect, delay, and filter any leakage from the primary containment before its release to the environment for all events up to and including those of design basis severity, and for some events of greater severity.

The secondary containment encloses plant areas that are accessible and, therefore, ventilated during normal operation. When a release of radioactivity is detected, normal ventilation is automatically isolated, and two ESFs--standby gas treatment system (SGTS) and reactor enclosure recirculation system (RERS)--assume control of air flow within and from the secondary containment. The SGTS and RERS filter the secondary containment atmosphere and exhaust sufficient filtered air to establish and maintain an internal pressure less than the outside atmospheric pressure. This negative pressure is to be sufficient to prevent unfiltered air leakage from the building. Radioactive iodine and particulate fission products would be substantially removed from the SGTS and RERS flow by safety-grade activated charcoal and high-efficiency particulate air filters. A filtered exhaust system also encloses the spent fuel pool.

The main steamlines pass through the secondary containment in going from the reactor to the turbine building. Any leakage of the main steamline isolation valves, therefore, could pass through those lines without being intercepted by the SGTS and RERS. To prevent this passage, a leakage control system is designed to collect main steamline isolation valve leakage and direct it into the secondary containment atmosphere and sumps, so that any airborne emissions are processed by the SGTS and RERS.

All mechanical systems mentioned above are designed to perform their functions given single failures, are qualified for their anticipated accident environments, and are supplied with emergency power from onsite diesel generators if normal offsite and station power is interrupted.

Much more extensive discussion of these design features may be found in the applicant's FSAR and the staff's SER (NUREG-0991). In addition, the implementation of the lessons learned from the TMI-2 accident--in the form of improvements in design, procedures, and operator training--will significantly reduce the likelihood of a degraded core accident that could result in large releases of fission products to the containment. The applicant will be required to meet the TMI-related requirements specified in NUREG-0737. As noted in Section 5.9.4.5(7), the relative improvement in safety from these actions has not been quantified in this statement.

(2) Site Features

The NRC's reactor site criteria, 10 CFR 100, require that the site for every power reactor have certain characteristics that tend to reduce the risk and potential impact of accidents. The discussion that follows briefly describes the Limerick site characteristics and how they meet these requirements.

First, the site has an exclusion area, as required by 10 CFR 100. The total site area is about 241 ha (595 acres). The exclusion area, located within the site boundary, is a circular area with a minimum distance of 762 meters (2500 feet) from the center of Unit 1 and Unit 2 to the exclusion area boundary. There are no residents within the exclusion area. The applicant owns all surface and mineral rights in the exclusion area and has the authority, as required by 10 CFR 100, to determine all activities in this area. Several state-maintained roads traverse the area, allowing access to the plant and to the Schuylkill River. One railroad and the Schuylkill River traverse the exclusion area. The Schuylkill River, including that section within the exclusion area, is used for recreational activities such as boating and fishing. In the event of an emergency, the applicant has made arrangements with Pennsylvania State Police to control access to and activities on the Schuylkill River and the roads traversing the exclusion area. The applicant also has made arrangements with Conrail for authority to control activities on the railroad traversing the exclusion area.

Second, beyond and surrounding the exclusion area is a low population zone (LPZ), also required by 10 CFR 100. The LPZ for the Limerick site is a circular area with a 1.27-mile (2.04-km) radius. Within this zone, the applicant must ensure that there is a reasonable probability that appropriate protective measures could be taken on behalf of the residents in the event of a serious accident. The applicant has indicated that 1177 persons lived within a 1.27-mile (2.04-km) radius in 1980. The major source of seasonal transients within the same 1.27-mile (2.04-km) radius of the site are the patrons of the Countryside Swim Club, which is located 1.2 miles west-southwest. The 1980 industrial employee population within the LPZ was 87 persons.

In case of a radiological emergency, the applicant has made arrangements to carry out protective actions, including evacuation of personnel in the vicinity of the plant (see also the following section on emergency preparedness).

Third, 10 CFR 100 also requires that the distance from the reactor to the nearest boundary of a densely populated area containing more than about 25,000 residents be at least one and one-third times the distance from the reactor to the outer boundary of the LPZ. Because accidents of greater potential hazards than those commonly postulated are highly improbable, although conceivable, it was considered desirable to add the population center distance requirement in 10 CFR 100 to provide for protection against excessive doses to people in large centers. Pottstown borough, with a 1980 population of 22,729, located 1.7 miles northwest of the site, is the nearest population center. This population center distance is at least one and one-third times the LPZ distance. The population density within a 30-mile (48.2-km) radius of the site was 1215 people/mi^2 (3147 people/km^2) in 1980 and is projected to increase to about 1966 people/mi^2 (5092 people/km^2) by the year 2020.

The safety evaluation of the Limerick site has also included a review of potential external hazards, that is, activities offsite that might adversely affect the operation of the nuclear plant and cause an accident. The review encompassed nearby industrial and transportation facilities that might create explosive, fire, missile or toxic gas hazards. The risk to the Limerick station from such hazards has been found to be negligible. A more detailed discussion of the compliance with the Commission's siting criteria and the consideration of external hazards is in the Limerick SER (NUREG-0991).

(3) Emergency Preparedness

The emergency preparedness plans, including protective action measures for Limerick station and environs, are in an advanced, but not yet fully completed stage. In accordance with the provisions of 10 CFR 50.47, effective November 3, 1980, no operating license will be issued to the applicant unless a finding is made by the NRC that the state of onsite and offsite emergency preparedness provides reasonable assurance that adequate protective measures can and will be taken in the event of a radiological emergency. Among the standards that must be met by these plants are provisions for two emergency planning zones (EPZs); a plume exposure pathway EPZ of about 10 miles (16 km) in radius and an ingestion exposure pathway EPZ of about 50 miles (80 km) in radius. Other standards include appropriate ranges of protective actions for each of these zones, provisions for dissemination to the public of basic emergency planning information, provisions for rapid notification of the public during a serious reactor emergency, and methods, systems, and equipment for assessing and monitoring actual or potential offsite consequences in the EPZs of a radiological emergency condition.

NRC and the Federal Emergency Management Agency (FEMA) have agreed that FEMA will make a finding and determination as to the adequacy of state and local government emergency response plans. NRC will determine the adequacy of the applicant's Emergency Response Plans with respect to the standards listed in 10 CFR 50.47(b), the requirements of Appendix E to 10 CFR 50, and the guidance contained in NUREG-0654/FEMA-REP-1, Revision 1, "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants," dated November 1980. After the above determinations by NRC and FEMA, the NRC will make a finding in the licensing process as to the state of preparedness. The NRC staff findings will be reported in a supplement to the SER. Although the presence of adequate and tested emergency plans cannot prevent an accident, it is the staff's judgment that such plans when implemented can mitigate the consequences to the public if an accident should occur.

5.9.4.5 Accident Risk and Impact Assessment

(1) Design-Basis Accidents

As a means of ensuring that certain features of the Limerick facility meet acceptable design and performance criteria, both the applicant and the staff have analyzed the potential consequences of a number of postulated accidents. Some of these could lead to significant releases of radioactive materials to the environment, and calculations have been performed to estimate the potential radiological consequences to persons off site. For each postulated initiating event, the potential radiological consequences cover a considerable range of values, depending upon the particular course taken by the accident and related conditions, including wind direction and weather prevalent during the accident.

In the Limerick safety analysis and evaluation, three categories of accidents have been considered by the applicant and the staff. These categories are based on probability of occurrence and include (1) incidents of moderate frequency (events that can reasonably be expected to occur during any year of operation); (2) infrequent accidents (events that might occur once during the lifetime of the plant); and (3) limiting faults (accidents not expected to occur but that have the potential for significant releases of radioactivity). The radiological consequences of incidents in the first category, also called anticipated operational occurrences, are discussed in Section 5.9.3. Some of the initiating events postulated in the second and third categories for the Limerick units are shown in Table 5.11b. These events are designated design-basis accidents in that specific design and operating features such as described in Section 5.9.4.4(1) are provided to limit their potential radiological consequences. Approximate radiation doses that might be received by a person at the

Table 5.11b Approximate doses during a 2-hour exposure at the exclusion area boundary*

Accidents and faults	Duration of release	Whole-body dose (rems)	Thyroid dose (rems)
INFREQUENT ACCIDENTS			
Category 2			
Fuel-handling accident	<2 hours	0.5	1
LIMITING FAULTS			
Category 3			
Main steamline break	<2 hours	1	80
Control rod drop	hours-days	0.1	0.7
Large-break LOCA	hours-days	5	300

*2500 feet (762 m) from centers of Unit 1 or 2. All numbers have been rounded to one significant digit.

exclusion area boundary are also shown in the table, along with a characterization of the duration of the releases. The results shown in the table reflect a conservative estimate of the potential upper bound of individual radiation exposures from the initiating accidents in Table 5.11b for the purpose of implementing the provisions of 10 CFR 100 and are reported in the staff's Safety Evaluation Report (SER, NUREG-0991). For these calculations, pessimistic (conservative) assumptions are made as to the course taken by the accident and the prevailing conditions. These assumptions include conservatively large amounts of radioactive material released by the initiating events, additional single failures in equipment, operation of ESFs in a degraded mode,* and very poor meteorological dispersion conditions. The results of these calculations show that radioiodine releases have the potential for offsite exposures ranging up to about 300 rems to the thyroid. For such an exposure to occur, an individual would have to be located at a point on the site boundary where the radioiodine concentration in the plume has its highest value and inhale at a breathing rate characteristic of jogging for a period of 2 hours during very poor atmospheric dispersion conditions. The health risk to an individual receiving such a thyroid exposure is the potential appearance of benign or malignant thyroid nodules in about 1 out of 10 cases, and the development of a fatal cancer in about 4 out of 1000 cases.

The staff experience has been that realistic dose estimates for a spectrum of accidents up to and including those as severe as design-basis accidents would result in values considerably lower than the design-basis accidents established for the purpose of implementing the provisions of 10 CFR Parts 50 and 100 as reviewed in the staff's SER.

None of the calculations of the impacts of design-basis accidents described in this section take into consideration possible reductions in individual or population exposures as a result of any protective actions.

(2) Probabilistic Assessment of Severe Accidents

In this and the following three sections, there is a discussion of the probabilities and consequences of accidents of greater severity than the design-basis accidents discussed in the previous section. As a class, they are considered less likely to occur, but their consequences could be more severe for both the plant itself and for the environment. These severe accidents (heretofore frequently called Class 9 accidents) can be distinguished from design-basis accidents in two primary respects: they all involve substantial physical deterioration of the fuel in the reactor core to the point of melting, and they involve deterioration of the capability of the containment structure to perform its intended function of limiting the release of radioactive materials to the environment. It should be understood that even the very severe reactor accidents, unlike weapons, would not result in blast and in high pressure- and high temperature-related consequences to the offsite public or to the environment.

The assessment methodology employed is essentially as described in the reactor safety study (RSS, WASH-1400) which was published in 1975 (NUREG-75/014), but includes improvements in the assessment methodology that were developed after

*The containment system, however, is assumed to prevent leakage in excess of that which can be demonstrated by testing, as provided in 10 CFR 100.11(a).

publication of the RSS* (such as better thermal-hydraulic models, more precise core melt phenomenology and containment response analysis). The assessment is also plant and site specific.

In the Limerick Environmental Report--Operating License stage (ER-OL) Revision 12, April 1983, the applicant has presented a plant- and site-specific probablistic assessment of severe accidents, including the effects of external events such as fires and earthquakes. The details of the applicant's analysis are contained in a supporting document, "Limerick Generating Station Severe Accident Risk Analysis (LGS-SARA)," which also includes information from the applicant's earlier submittal "Limerick Generating Station Probabilistic Risk Assessment (LGS-PRA)." As a direct result of the applicant's efforts in performing the probabilistic assessment, several risk reduction modifications to the plant design were implemented during its construction. These modifications have been reviewed by the staff and are incorporated into the staff's analysis. The NRC staff contracted with the Brookhaven National Laboratory (BNL) to review portions of the LGS-SARA. The results of BNL's review of LGS-PRA is reported in NUREG/CR-3028, and that of the earthquake and fire hazards from the SARA is summarized in the draft report attached to the staff's letter to the applicant dated August 31, 1983. By letter dated March 13, 1984 the applicant informed the staff that errors in the LGS-SARA consequence analysis had been discovered. The staff has determined that correction of the applicant's errors will not change the conclusions contained herein. The results of an independent staff analysis of severe accidents are summarized below. Neither the applicant's analysis nor the staff's analysis includes the potential effects of sabotage; such an analysis is considered to be beyond the state of the art of probabilistic risk assessment. However, the staff judges that the additional risks from severe accidents initiated by sabotage are within the uncertainties of risks presented for the severe accidents considered here.

Accident sequences initiated by both internal and external causes that are used in the staff analysis are described in Appendix H to this report, based on information provided by BNL. Accident sequences are grouped into "release categories" based upon similarities of the sequences regarding core-melt accident progression, containment failure characteristics, and the parameters of atmospheric release of radionuclides required for consequence analysis.

Included in the list of potential accident initiators that are called external events are fires and earthquakes. The staff concurs with the SARA findings that the hazards due to other external events such as floods, tornadoes, transportation accidents, industrial accidents, and turbine missiles do not contribute significantly to the risk from severe accidents.

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*However, there are large uncertainties in the assessment methodology and the results derived from its application. A discussion of the uncertainties is provided in section 5.9.4.5(7). Large uncertainties in event frequencies and other areas of risk analysis arise, in part, from similar causes in all plant and site assessments; hence the results are better used in carefully constructed comparisons rather than as absolute values. External event frequencies used here are, however, more representative of the Limerick site than those used in the RSS.

Table 5.11c provides information used in the staff's consequence assessment for each specific release category and summarizes the BNL analysis described in Appendix H. The information includes time estimates from termination of the fission process during the accident until the beginning of release to the environment (release time), duration of the atmospheric release, warning time for offsite evacuation, and estimates of the energy associated with the release, height of the release location above the ground level, and fractions of the core inventory (see Table 5.11a) of seven groups of radionuclides in the release. The radionuclide release fractions shown in Table 5.11c were derived using WASH-1400 radiochemistry assumptions of fission product releases from fuel and their attenuation through various elements of the primary system and containment such as the suppression pool and aerosol transport in the containment building as described in Appendix H. The number in parentheses following the designation of each release category in Table 5.11c indicates its relative rank in terms of the magnitude of the core-fraction of cesium estimated to be in the release. Cesium was chosen because of its biological significance.

The BNL-calculated mean value (i.e., the point estimate or the best estimate) of probability associated with each release category used in the staff analysis, is shown in Table 5-11d (see Appendix H and Section 5.9.4.5(7)). In this table, the probability of each accident sequence or release category is shown in two separate parts based on the cause of the accident. One contribution to the probability is ascribed to the accident-initiating events that include plant internal causes, fires, and earthquakes of low to medium severity (effective peak ground acceleration less than 0.4 g; that is, Modified Mercalli (MM) intensity scale VIII or lower) (see Appendix H). In Table 5.11c of the DES supplement release fractions for four release categories were found to be in error (IV-T/DW, IV-T/WW, IV-T/WW and IV-A/DW) and these have been corrected. The second contribution to the probability is ascribed to very severe regional earthquakes (effective peak ground acceleration equal to or greater than 0.4 g; that is, MM intensity scale IX or higher) (see Appendix H) as potential cause of reactor accidents, which would also alter offsite conditions adversely to seriously hamper emergency responses that would mitigate the consequences of such accidents. (Appendix I provides a description of potential offsite damages from earthquakes of various intensities.) As in the RSS, there are substantial uncertainties in these probabilities. This is due, in part, to difficulties associated with the quantification of human error and to inadequacies (1) in the data base on failure rates of individual plant components (NUREG/CR-0400), and (2) in the data base on external events and their effects on plant systems and components that are used to calculate the probabilities.

Analyses of risks have indicated that reactor accidents having mean likelihoods of less than 10^{-9} per reactor-year (i.e., less than once in a billion reactor years), even considering the uncertainties of such estimates, are unlikely to contribute substantially to estimated risks. For this reason, and because of the low probabilities of occurrence of these accidents, the staff has omitted from any further discussion the Table 5-11c accidents and release categories for which the mean probability in Table 5-11d is estimated to be less than 10^{-9} per reactor-year.

The magnitudes (curies) of radioactivity release to the atmosphere for each accident sequence or release category are obtained by multiplying the release

Table 5.11c Summary of the atmospheric release specifications used in consequence analysis for Limerick Units 1 and 2[a]

Release category[b]	Release time (hr)	Release duration (hr)	Warning time for evacuation (hr)	Energy release (10^6 Btu/hr)	Release height (m)	Fractions of Core Inventory Released: Xe-Kr	Organic I[c]	Inorganic I	Cs-Rb	Te-Sb	Ba-Sr	Ru[d]	La[e]
I-T/DW(22)*	5	0.5	4	100	30	1	7(-3)**	2(-3)	2(-2)	8(-2)	1(-3)	5(-3)	1(-3)
I-T/WW(25)	5	0.5	4	100	30	1	7(-3)	1(-4)	3(-4)	1(-3)	2(-5)	7(-5)	1(-5)
I-T/$\overline{WW}$(24)	5	0.5	4	100	30	1	7(-3)	2(-4)	9(-4)	2(-3)	8(-5)	1(-4)	3(-5)
I-T/SE(14)	2	0.5	1	100	30	1	--	1(-1)	1(-1)	4(-1)	1(-2)	4(-1)	2(-3)
I-T/HB(20)	2	0.5	1	100	30	1	--	2(-1)	6(-2)	1(-1)	7(-3)	8(-2)	1(-5)
I-T/LGT(26)***	2	3	0	1	30	0.7	--	3(-3)	1(-4)	5(-4)	2(-5)	3(-5)	6(-6)
I-T/$\overline{LGT}$(18)	2	3	0	1	30	0.7	--	2(-2)	1(-1)	5(-2)	2(-3)	3(-3)	6(-4)
II-T/WW(8)	20	4	5	1	30	1	7(-3)	7(-1)	3(-1)	2(-1)	4(-2)	4(-2)	3(-3)
II-T/SE(14)	30	0.5	7	100	30	1	--	1(-1)	1(-1)	4(-1)	1(-2)	4(-1)	2(-3)
III-T/WW(10)	3	1	2	100	30	1	7(-3)	8(-2)	2(-1)	6(-1)	2(-2)	4(-2)	7(-3)
III-T/SE(5)	2	0.5	1	100	30	1	--	4(-1)	5(-1)	5(-1)	5(-2)	5(-1)	3(-3)
III-T/HB(20)	2	0.5	1	100	30	1	--	2(-1)	6(-2)	1(-1)	7(-3)	8(-2)	1(-5)
III-T/LGT(26)	0.5	4	0	1	30	0.7	--	3(-3)	1(-4)	5(-4)	2(-5)	3(-5)	6(-6)
III-T/$\overline{LGT}$(18)	0.5	4	0	1	30	0.7	--	2(-2)	1(-1)	5(-2)	2(-3)	3(-3)	6(-4)
IV-T/DW(2)	1	3	0.5	1	30	1	7(-3)	5(-1)	5(-1)	5(-1)	6(-2)	9(-2)	7(-3)
IV-T/WW(4)	1	3	0.5	1	30	1	7(-3)	5(-1)	5(-1)	5(-1)	6(-2)	8(-2)	6(-3)
IV-T/$\overline{WW}$(3)	1	3	0.5	1	30	1	7(-3)	5(-1)	5(-1)	5(-1)	6(-2)	9(-2)	7(-3)
IV-T/SE(5)	2	0.5	2	100	30	1	--	4(-1)	4(-1)	5(-1)	5(-2)	5(-1)	3(-3)
I-S/DW(23)	5	0.5	4	100	30	1	7(-3)	3(-3)	5(-3)	3(-3)	6(-4)	3(-4)	4(-4)
IV-A/DW(1)	1	3	0.5	1	30	1	7(-3)	5(-1)	5(-1)	5(-1)	6(-2)	9(-2)	7(-3)
IS-C/DW(13)	0	3	0.4	1	30	1	7(-3)	8(-2)	1(-1)	6(-1)	7(-3)	8(-2)	7(-3)
IS-C/SE(14)	1	0.5	1	100	30	1	--	1(-1)	1(-1)	4(-1)	1(-2)	4(-1)	2(-3)
IS-$\overline{C}$/DW(12)	1	3	1	1	30	1	7(-3)	8(-2)	1(-1)	6(-1)	8(-3)	1(-1)	7(-3)
IS-$\overline{C}$/SE(14)	2	0.5	2	100	30	1	--	1(-1)	1(-1)	4(-1)	1(-2)	4(-1)	2(-3)
S-H20/$\overline{WW}$(11)	3	5	3	1	30	1	7(-3)	1(-1)	2(-1)	3(-1)	1(-2)	5(-2)	4(-3)
S-H20/SE(5)	4	0.5	4	100	30	1.	--	4(-1)	4(-1)	5(-1)	5(-2)	5(-1)	3(-3)
S-$\overline{H20}$/$\overline{WW}$(9)	3	4	3	1	30	1	7(-3)	3(-1)	3(-1)	4(-1)	3(-2)	6(-2)	5(-3)

[a]See Section 5.9.4.5(7) for discussion of uncertainties. Estimated numbers were rounded to one significant digit only for the purpose of this table.

[b]See Appendix H for designations and descriptions of the release categories.

[c]Organic iodine is added to inorganic iodine for consequence calculations because organic iodine is likely to be converted to inorganic or particulate forms during environmental transport.

[d]Includes Ru, Rh, Co, Mo, Tc.

[e]Includes Y, La, Zr, Nb, Ce, Pr, Nd, NP, Pu, Am, Cm.

*Number in parentheses indicates relative ranking of the release category according to cesium fraction.

**7(-3) = 7×10^{-3} = 0.007.

***This release category is combined with III-T/LGT in consequence analysis.

Table 5.11d Summary of the calculated mean (point estimate) probabilities of atmospheric release categories

Release category	Probability of the release category initiated by internal causes, fires, and low to moderately severe earthquakes (per reactor-year)	Probability of the release category initiated by severe earthquakes (per reactor-year)
I-T/DW	2(-5)*	6(-7)
I-T/WW	2(-5)	5(-7)
I-T/$\overline{WW}$	2(-6)	6(-8)
I-T/SE	8(-9)	2(-10)***
I-T/HB	8(-7)	2(-8)
I-T/LGT**	2(-5)	5(-7)
I-T/$\overline{LGT}$	2(-5)	6(-7)
II-T/WW	2(-6)	2(-8)
II-T/SE	4(-10)***	4(-10)***
III-T/WW	2(-6)	4(-7)
III-T/SE	3(-10)***	7(-11)***
III-T/HB	3(-8)	7(-9)
III-T/LGT	7(-7)	2(-7)
III-T/$\overline{LGT}$	9(-7)	2(-7)
IV-T/DW	2(-7)	5(-8)
IV-T/WW	2(-7)	4(-8)
IV-T/$\overline{WW}$	2(-8)	5(-9)
IV-T/SE	3(-11)***	1(-11)***
I-S/DW	4(-8)	0
IV-A/DW	5(-9)	0
IS-C/DW	1(-8)	1(-7)
IS-C/SE	1(-12)***	1(-11)***
IS-$\overline{C}$/DW	1(-7)	9(-7)
IS-$\overline{C}$/SE	1(-11)***	9(-11)***
S-H2O/$\overline{WW}$	1(-8)	4(-8)
S-H2O/SE	1(-12)***	4(-12)***
S-$\overline{H2O}$/$\overline{WW}$	1(-8)	4(-7)
Total probability per reactor-year	9(-5)	5(-6)

*2(-5) = 2 x 10^{-5} = .00002
**This release category is combined with III-T/LGT in consequence analysis.
***Any release category with probability less than 10^{-9} per reactor-year is omitted from consequence analysis because of its low probability and insignificant contribution to risks.

NOTE: Please see Section 5.9.4.5(7) for discussion of uncertainties. Estimated numbers were rounded to one significant digit only for the purpose of this table.

fractions shown in Table 5-11c by the amounts that would be present in the core at the time of the hypothetical accident and by depletion factors as a result of inplant radioactive decay during the release time. The core inventory of radionuclides are shown in Table 5.11a for Units 1 and 2 at a core thermal power level of 3458 MWt. This is the power level used in the FSAR for analysis of radiological consequences and is used here instead of the 3293 MWt expected maximum power to correct for power density variations and instrument error in measurement of power levels normally present in operating reactors. The 54 nuclides shown in the table represent those (of the hundreds actually expected to be present in the operating plant) that are potentially major contributors to the health and economic effects of severe accidents. They were selected on the basis of the half-life of the nuclide, consideration of the health effects of daughter products, and the approximate relative offsite dose contribution.

The potential radiological consequences of these releases have been calculated by the computer code CRAC, based on the consequence model used in the RSS (see NUREG-0340), adapted and modified as described below to apply to a specific site. The essential elements are shown in schematic form in Figure 5.4a. Environmental parameters specific to the site of Limerick station have been used and include

(1) meteorological data for the site representing a full year (1976) of consecutive hourly measurements and seasonal variations with good data recovery characteristics (annual average probabilities of wind blowing into 16 directions of the compass are shown in Table 5.11e)

(2) projected population for the year 2000 extending throughout regions of 80-km (50-mile) and 563-km (350-mile) radius from the site

(3) the habitable land fraction within a 563-km (350-mile) radius

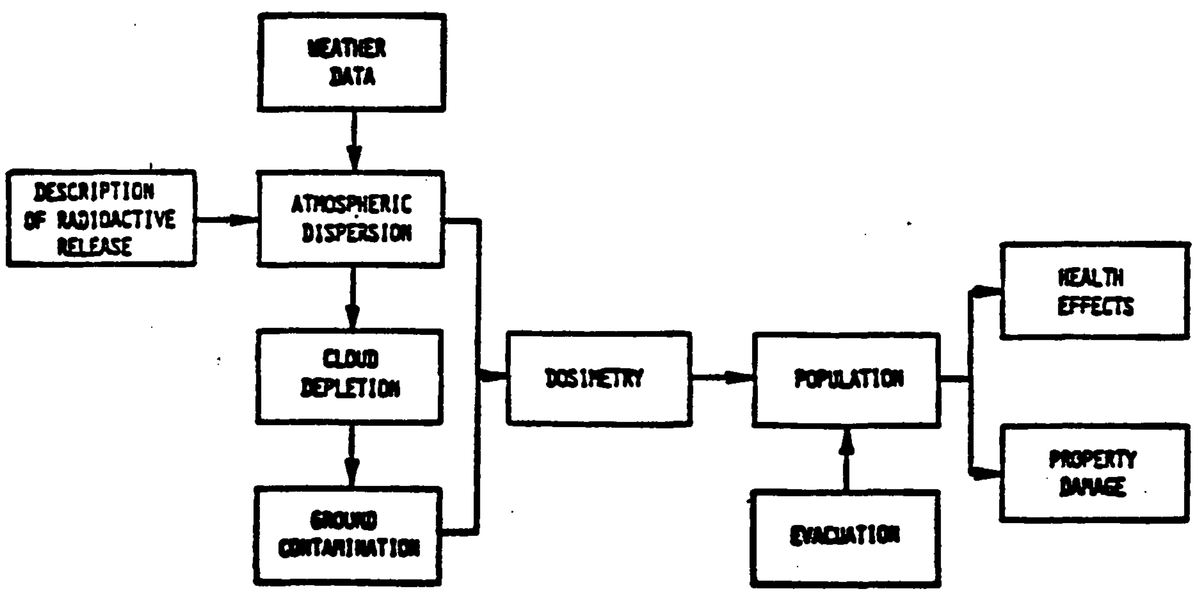

Figure 5.4a Schematic outline of consequence model

Table 5.11e Annual average wind-direction probabilities for the Limerick site based on data for the year 1976

Wind blowing toward the direction	Probability (fraction of the year)
N	0.07
NNE	0.07
NE	0.06
ENE	0.05
E	0.10
ESE	0.16
SE	0.11
SSE	0.04
S	0.04
SSW	0.03
SW	0.03
WSW	0.04
W	0.07
WNW	0.03
NW	0.04
NNW	0.06
Total	1.00

(4) land-use statistics on a countywide basis within and statewide basis outside of a 80-km (50-mile) region, including farm land values, farm product values including dairy production, and growing season information, for the counties, the State of Pennsylvania and each surrounding state within the 563-km (350-mile) region

For the region beyond 563 km (350 miles), the U.S. average population density was assumed.

The calculation was extended out to 3200 km (2000 miles) from the site, to account for the residual radionuclides that would remain in the atmosphere at large distances, with rain assumed in the interval between 563 km and 3200 km to deplete the plume of all non-noble-gas inventory. To obtain a probability distribution of consequences, calculations were performed assuming the occurrence of each release category at each of 91 different "start" times distributed throughout a 1-year period. Each calculation utilized site-specific hourly meteorological data and seasonal information for the period following each "start" time.

The consequence model was also used to evaluate the consequence reduction benefits of offsite emergency response such as evacuation, relocation, and other protective actions. Early evacuation and relocation of people would considerably reduce the exposure from the radioactive cloud and the contaminated ground in the wake of the cloud passage. The evacuation model used (see Appendix J) has been revised from that used in the RSS for better site-specific application. In the staff calculation, three sets of assumptions were made about the short-term emergency response that would likely be undertaken to minimize the severe accident health effects from early or short-term radiological exposure. Table 5.11f lists the assumptions and parameters for each emergency response scenario evaluated.

The first set of parameters assumes evacuation of the population within 10 miles (16 km). The effective evacuation speed in Table 5.11f is based on an evaluation made by the applicant's contractor, NUS Corporation, in an evacuation time estimate study (NUS, 1980). The estimate of the delay time before evacuation in the same study has been rejected by the applicant in LGS-SARA and, therefore, is not used in the staff analysis. Instead, the value of delay time in Table 5.11f is a staff assumption and is based partly on considerations of the NRC requirement regarding prompt notification of the public of the emergency, and partly on the staff judgment regarding the time people would take preparing for evacuation after being notified of the emergency, for a high population density site, during normal to moderately adverse conditions such as snow, ice, hurricane, low to moderately severe earthquakes (up through MM intensity scale VIII), etc. The values of delay time before evacuation and effective evacuation speed used in the staff analysis are assumed only to be average values. Within the 10-mile emergency planning zone there normally would be some facilities (such as nursing homes, hospitals, prisons, schools, etc.) where special equipment or personnel may be required to effect evacuation, and there may be some people who choose not to evacuate. Therefore, actual effectiveness could be greater or less than that characterized by the average values. Because special consideration will be given in emergency planning for Limerick to any unique aspects of dealing with special facilities, it is not expected that actual evacuation effectiveness would be very much less than that modeled by the average values used here. For areas beyond 10 miles (16 km), however, the parameters selected reflect the assumptions that an extension of emergency response would occur during a large accident and people would be advised to leave areas that would be considered to be highly contaminated (see below for criterion), i.e., people would relocate. Relocation of the public from the highly contaminated areas beyond 10 miles (16 km) is assumed to take place 12 hours after plume passage. The criterion for this relocation is whether the projected 7-day ground dose to the total bone marrow, as projected by field measurements, would exceed 200 rems (which is only slightly above the average threshold exposure for potential early fatality with minimal medical treatment); otherwise people in highly contaminated areas are assumed to be relocated within 7 days. The offsite emergency response mode characterized by these assumptions is designated Evac-Reloc.

The second set of parameters reflects the hypothesis that the planned evacuation may not take place in a real situation for one or more reasons such as short warning time, indecision regarding whether to evacuate or not because of uncertain plant conditions, or adverse site conditions that would cause long delay before evacuation. In lieu of evacuation, it was assumed that people in the footprint of the plume within 10 miles (16 km) would leave the area (i.e., relocate) 6 hours after plume passage. This 6-hour relocation time is similar to the time for evacuation assumed in the first set based on 2 hours delay and about 2.5 miles per hour evacuation speed. Beyond 10 miles (16 km), relocation

Table 5.11f Emergency response assumptions for each reactor unit

Emergency response set no.*	Evacuation distance (mi)**	Delay time (hr)	Effective evacuation speed (mph)	Effective downwind distance moved*** (mi)	Relocation zone size (mi) Zone A†	Relocation zone size (mi) Zone B†	Zone B relocation relocation time (hr)	Zone B relocation dose criterion (bone marrow dose projected for 7 days) (rems)	Shielding protection factor (fraction): During evacuation, plume/ground	Shielding protection factor (fraction): Other times, plume/ground
1	10	2	2.5	15	0	>10	12	200	1¶/0.5¶	0.75¶¶/0.33¶¶
2	N/A††	N/A	N/A	N/A	10†††	>10	12	200	N/A	0.75¶¶/0.33¶¶
3	N/A	N/A	N/A	N/A	0	>0	24	200	N/A	1.0¶¶¶/0.5¶¶¶

*Sets 1, 2, and 3 are also identified as Evac-Reloc, Early Reloc, and Late Reloc, respectively, in text, tables, and figures.

**To change miles to km, multiply the values shown by 1.609.

***An artificial parameter used only to represent a realistic path-length for each evacuee over which radiation exposure to the evacuee is calculated in the CRAC code.

†Zone A is the 10-mile plume exposure pathway emergency planning zone; Zone B is the area outside Zone A.

††N/A - Not Applicable.

†††Relocation takes place 6 hours after ground contamination.

¶During evacuation, automobiles are assumed to provide essentially no shielding to gamma rays from the plume and some shielding to gamma rays from the contaminated ground. The selected values of shielding protection factors for the plume and the ground during evacuation are taken from Table VI 11-13 of Appendix VI of WASH-1400.

¶¶At other times than during evaucation, shielding protection factors are the average values representative of normal activities of the people during which some people are indoors and some are outdoors. The selected values of the shielding protection factors for the plume and the ground for this situation are taken from Table VI 11-13 of Appendix VI of WASH-1400.

¶¶¶During an abnormal situation in the site region caused by a external event such as a severe earthquake, it is assumed that many of the buildings may not remain habitable to provide shielding protection to the people against gamma rays from the plume. So, the shielding factor for the plume is taken to be 1. However, the nature of the ground surface is assumed to become altered by debris and possibly mud/slush/water generated from a severe earthquake. So, the ground shielding factor (provided by the altered ground and whatever building structures that would still have remained intact) of 0.5 was selected for this scenario, which is about midway between the values 0.33 for normal situation and 0.7 for an ordinary and uncovered ground surface.

NOTE: Please see Section 5.9.4.5(7) for discussion of uncertainties.

was assumed as in the previous set of assumptions. The offsite emergency response mode characterized by these assumptions is designated Early Reloc and was used for an alternative risk analysis.

The third set of parameters reflects a radiological emergency response situation hampered by a severe type of external event, such as a severe regional earthquake, which would seriously limit the ability to evacuate, and would also eliminate or reduce the shielding protection that the public would otherwise experience. However, relocation of the public from highly contaminated areas 24 hours after plume passage was assumed. The criterion for this relocation was the same as in the first set of assumptions, but relocation was assumed to extend outward from the site exclusion area boundary (762 meters, as opposed to the 10-mile (16-km) EPZ boundary); otherwise people are assumed to be relocated within 7 days. The offsite emergency response mode characterized by this third set of assumptions is designated Late Reloc.

The environmental protective actions considered as part of relatively long-term offsite emergency response to reduce health effects from chronic exposure include: (1) either complete denial of use (interdiction), or permitting use only at a later time after appropriate decontamination, of food stuffs such as crops and milk; (2) decontamination of severely contaminated land and property when it is considered to be economically feasible to lower the levels of contamination to protective action guide (PAG) levels*; and (3) denial of use (interdiction) of severely contaminated land and property for varying periods of time until the contamination levels are reduced by radioactive decay and weathering to such values that land and property can be economically decontaminated as in (2) above. These actions would reduce radiological exposures and health effects to the people from immediate and/or subsequent use of or living in the contaminated environment, but would also result in economic costs to implement them. Lowering the PAG levels would lower the delayed health effects but would increase costs.

Estimates of meteorology-averaged societal consequences of several types conditional upon occurrence of each release category in Table 5.11c are tabulated in Appendix K. For each release category, separate estimates are provided using each of the offsite emergency response modes in Table 5.11f. These conditional mean values are of use only in judging the relative severity of each release category and they cannot be used directly for risk assessment without simultaneous association with the probability of the release category to which the consequences are due. Therefore, in the following paragraphs, the impacts of severe accidents in the Limerick reactors are appropriately weighted by their probabilities.

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*PAG levels used in CRAC analyses are not to be confused with those drafted by the U.S. Environmental Protection Agency (EPA-520/1-75-001, September 1975), or by the U.S. Department of Health and Human Services (47 FR 47073, October 22, 1982), for reactor accidents. PAG levels used in CRAC are defined in Table VI 11-6 of WASH-1400, and were based on the recommendations of the former U.S. Federal Radiation Council and the British Medical Research Council. However, for control of long-term external irradiation, the PAG level for urban areas in WASH-1400 Table VI.11-6 was used in CRAC for all areas (urban and rural).

The consequences and risks* of severe accidents in the Limerick reactors initiated by plant internal causes, fires, and low to moderately severe earthquakes were evaluated using the release categories in Table 5.11c, the corresponding probabilities in Table 5.11d, and the parameters of the Evac-Reloc mode of offsite emergency response in Table 5.11f. The consequences and risks of accidents initiated by very severe regional earthquakes that could also affect the offsite conditions so as to seriously hamper evacuation or early relocation were evaluated using the accident parameters in Table 5.11c, the corresponding probabilities in Table 5.11d, and the parameters of the Late Reloc mode of offsite emergency response in Table 5.11f. Finally, the overall evaluation of consequences and risks of reactor accidents at Limerick from internal causes, fires, and low to high severity earthquakes is made by combining the results for Evac-Reloc and Late Reloc offsite emergency response modes.

The results of the staff calculations using the consequence model are radiological doses to individuals and to populations, health effects that might result from these exposures, costs of implementing protective actions and costs associated with property damage by radioactive contamination, and land area that would be subject to long-term interdiction. These results are presented and discussed below. Breakdowns for each type of consequence in terms of contributions from accidents initiated by severe earthquakes and from accidents initiated by other causes considered in the analysis are presented in Appendix L.

An alternative overall evaluation of consequences and risk in which the Evac-Reloc mode of offsite emergency response is replaced by the Early Reloc mode is presented in Appendix M. The staff critique of the principal aspects of the applicant's consequence analysis in the Environmental Report-Operating License stage (ER-OL), which is identified to be the same as in LGS-SARA, is provided in Appendix N.

There are large uncertainties in each facet of the estimates of consequences both in the staff analysis and the applicant's analysis (see Section 5.9.4.5(7)).

(3) Dose and Health Impacts of Atmospheric Releases

The results of the staff calculations of the environmental dispersion of radioactive releases to the atmosphere and the radiological dose to people and health impacts performed for the Limerick station and site are presented in the form of probability distributions in Figures 5.4b through 5.4f and are included in the impact summary Table 5.11g. The graphs in Figures 5.4b through 5.4f (and in similar Figures 5.4g and 5.4h introduced later) display a type of probability distribution called a complementary cummulative distribution function (CCDF). CCDFs are intended to show the relationship between the probability of a particular type of consequence being equaled or exceeded and the magnitude of the consequence. These graphs are useful in visualizing the degree to which the probability of occurrence of consequences decreases as the magnitude of the consequence increases. Probability per reactor-year* is the chance that a given event would occur or a given consequence magnitude would be exceeded in 1 year

*Risk of a particular kind of consequence is to be understood as the average value of several estimates of the product of magnitude of the particular consequence and its associated probability.

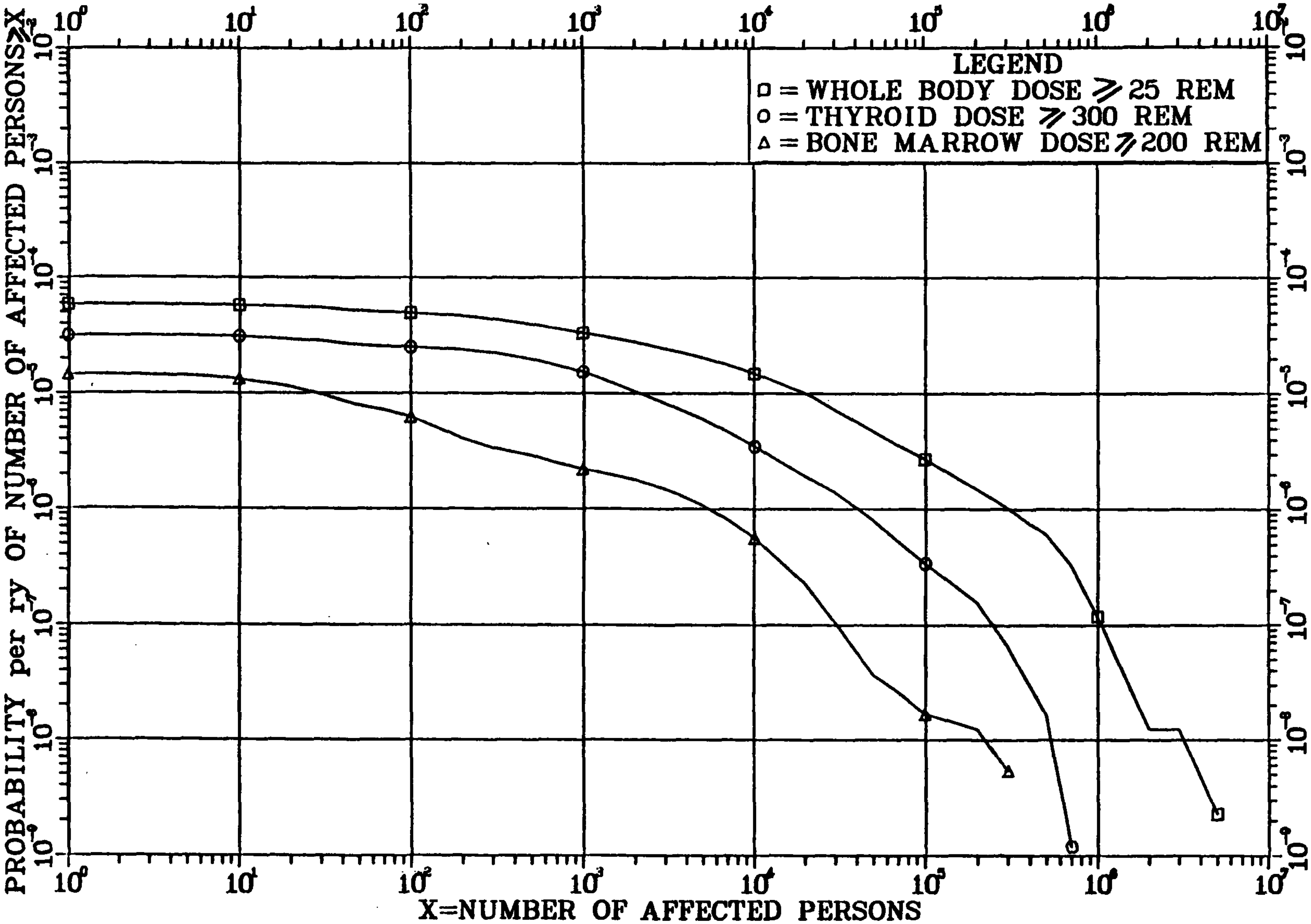

Figure 5.4b Probability distributions of individual dose impacts

NOTE: See Section 5.9.4.5(7) for a discussion of uncertainties.

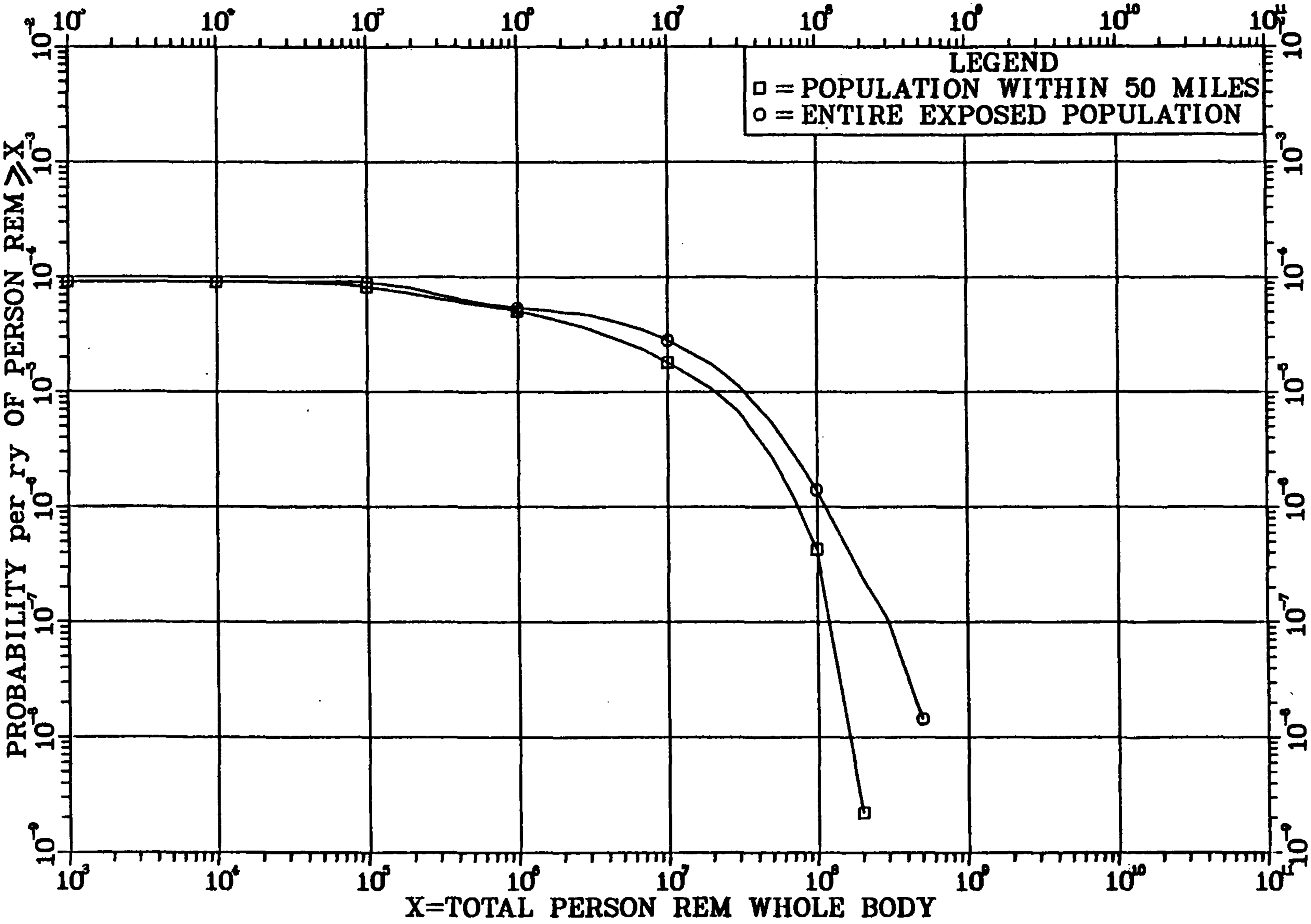

Figure 5.4c Probability distributions of population exposures

NOTES: 1. The average annual dose to the population within 50 miles resulting from natural background radiation is about 800,000 person-rems.

2. See Section 5.9.4.5(7) for a discussion of uncertainties.

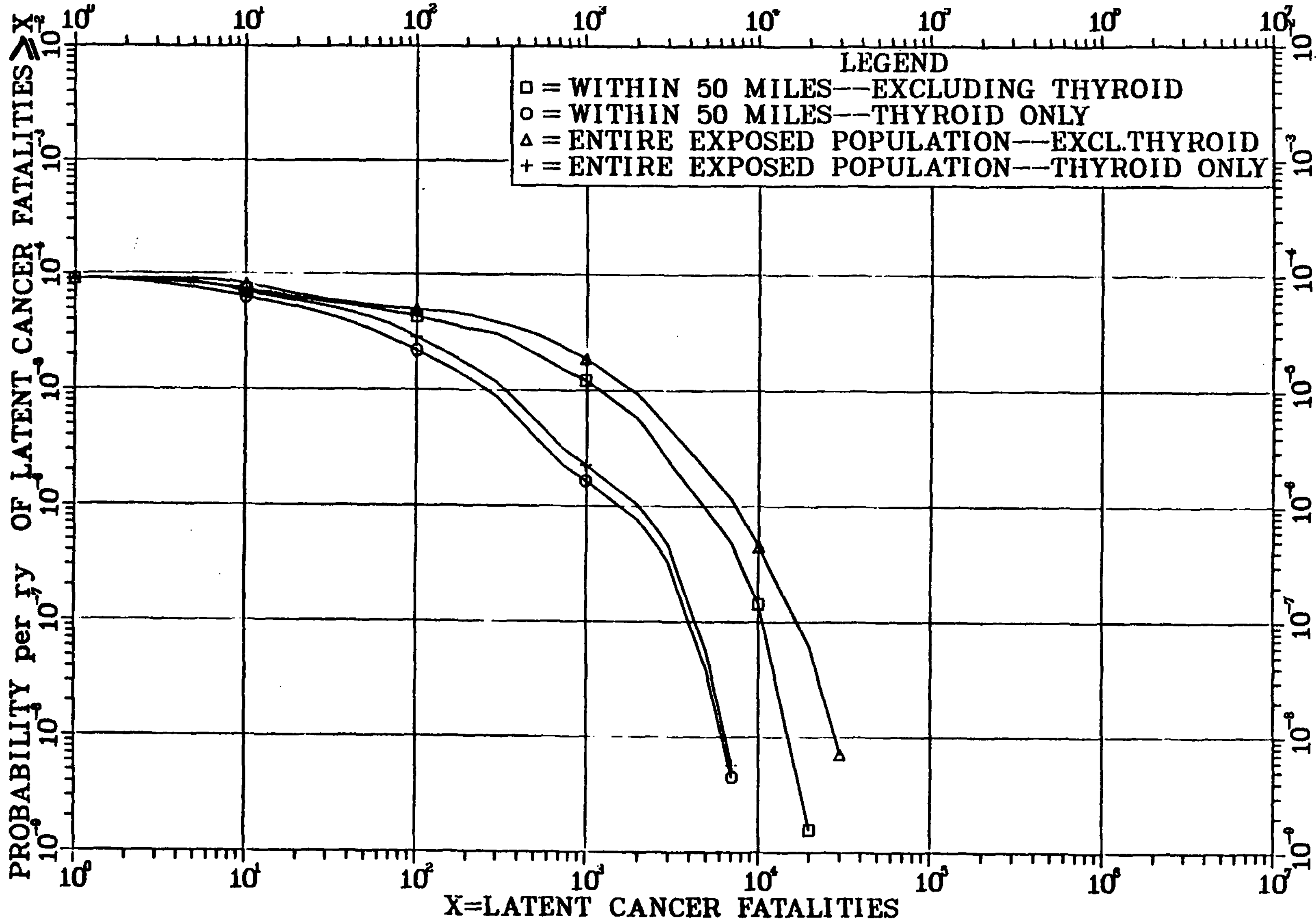

Figure 5.4d Probability distributions of cancer fatalities

NOTE: See Section 5.9.4.5(7) for a discussion of uncertainties.

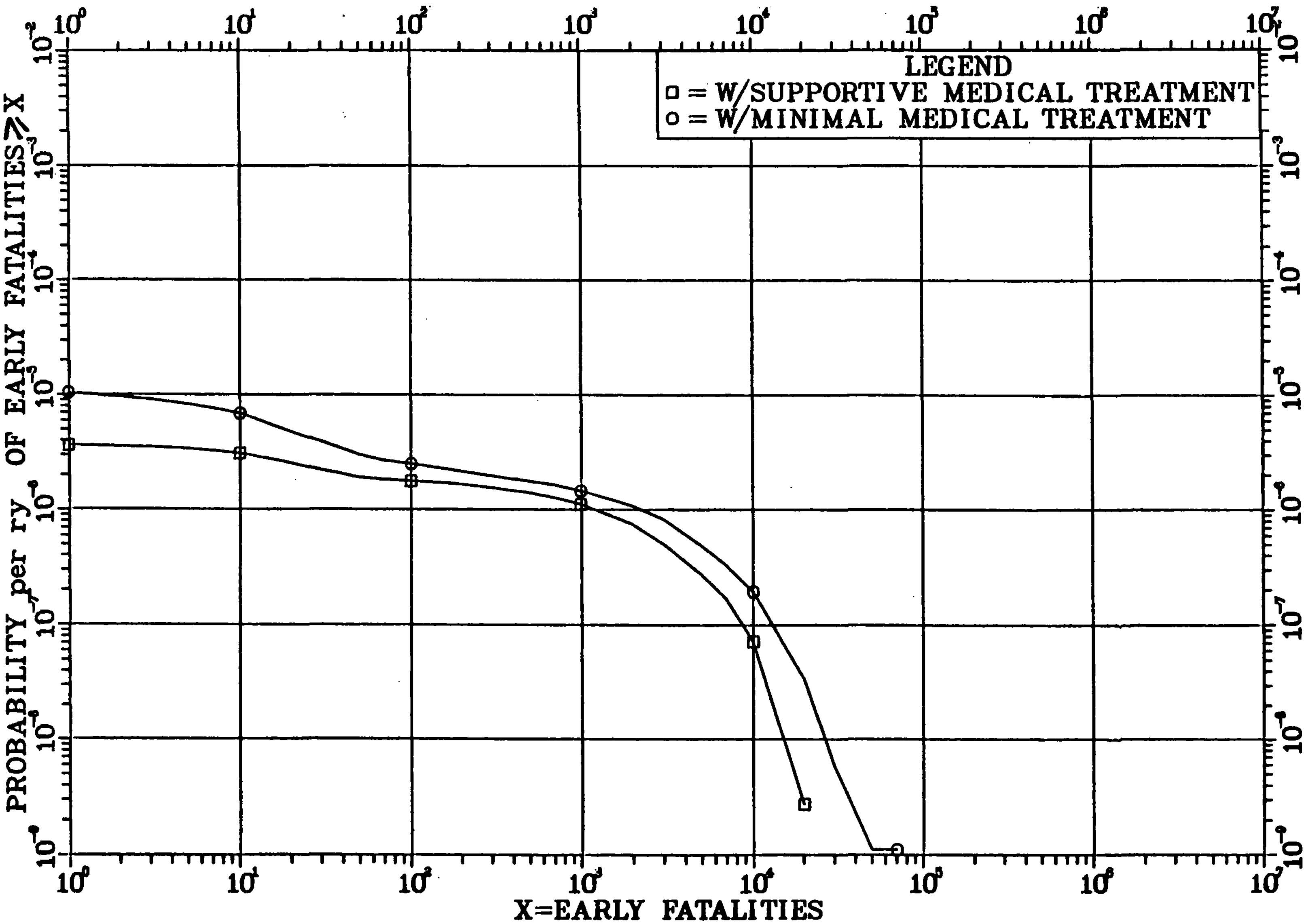

Figure 5.4e Probability distribution of early fatalities

NOTE: See Section 5.9.4.5(7) for a discussion of uncertainties.

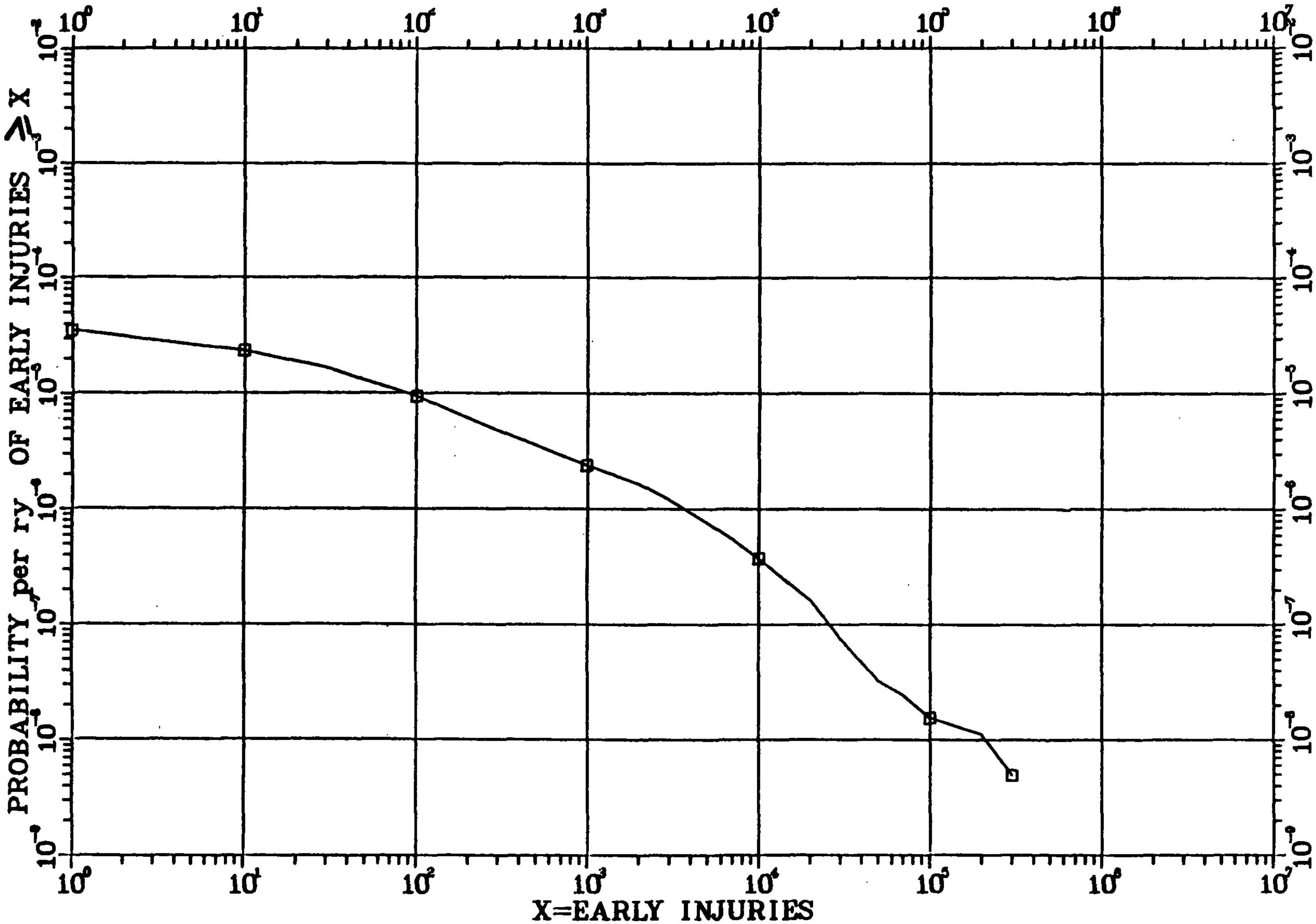

Figure 5.4f Probability distribution of early injuries

NOTE: See Section 5.9.4.5(7) for a discussion of uncertainties.

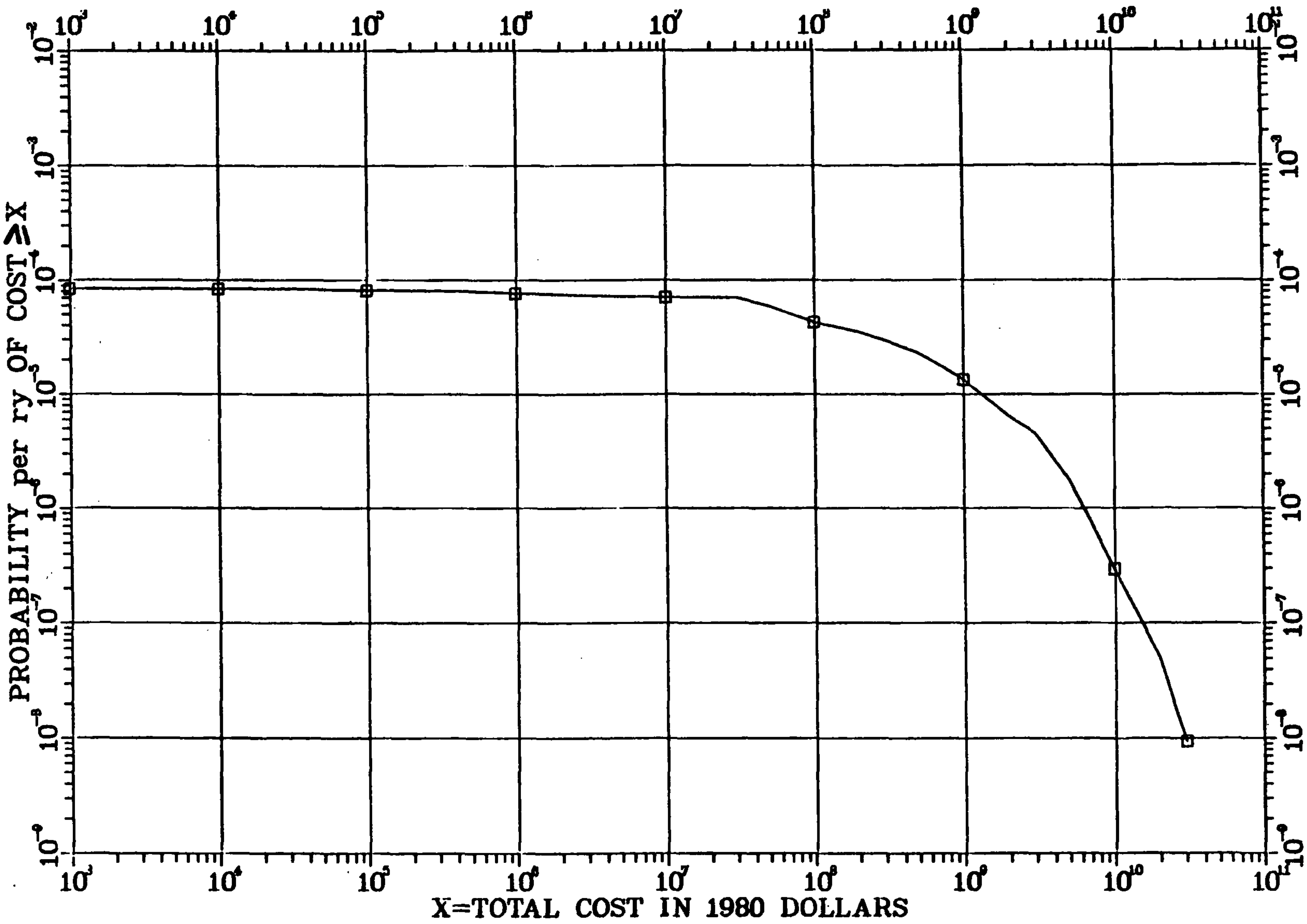

Figure 5.4g Probability distribution of cost of mitigation measures

NOTE: See Section 5.9.4.5(7) for a discussion of uncertainties.

Table 5.11g Summary of environmental impacts and probabilities

Probability of impact per reactor-year	Persons exposed over			Population exposure, whole body (million person-rems)*		Latent cancer fatalities (persons)				Early fatalities (persons)		Early injuries (persons)	Cost of offsite mitigation measures (millions of 1980 $)	Land area for long-term interdiction (millions of m²)**
						Excluding thyroid		Thyroid						
	300 rems thyroid dose	200 rems total marrow dose	25 rems whole body dose	50 miles (80 km)	Total	50 miles (80 km)	Total	50 miles (80 km)	Total	With supportive medical treatment	With minimal medical treatment			
10^{-4}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10^{-5}	2(3)	3(1)	2(4)***	2(1)	3(1)	1(3)	2(3)	3(2)	3(2)	0	1(0)	9(1)	1(3)	4(1)
5×10^{-6}	7(3)	2(2)	5(4)	4(1)	5(1)	2(3)	3(3)	4(2)	6(2)	0	2(1)	2(2)	3(3)	7(1)
10^{-6}	4(4)	5(3)	3(5)	7(1)	1(2)	5(3)	7(3)	2(3)	2(3)	1(3)	2(3)	4(3)	6(3)	1(2)
10^{-7}	2(5)	3(4)	1(6)	1(2)	3(2)	1(4)	2(4)	4(3)	4(3)	9(3)	1(4)	3(4)	2(4)	3(2)
10^{-8}	5(5)	2(5)	3(6)	2(2)	5(2)	2(4)	3(4)	6(3)	6(3)	2(4)	3(4)	2(5)	3(4)	7(2)
See Figure	5.4b	5.4b	5.4b	5.4c	5.4c	5.4d	5.4d	5.4d	5.4d	5.4e	5.4e	5.4f	5.4g	5.4h

*About 260 cases of genetic effects may occur in the succeeding generations per million person-rem to the exposed generation.

**About 2.6 million square meters equals 1 square mile.

***2(4) = 2×10^4 = 20000.

NOTE: Please see Section 5.9.4.5(7) for discussion of uncertainties. Estimated numbers were rounded to one significant digit only for the purpose of this table.

of operation for one reactor. Different accident releases and atmospheric dispersion conditions, source-term magnitudes, and dose effects result in wide ranges of calculated magnitudes of consequences. Similarly, probabilities of equaling or exceeding a given consequence magnitude would also vary over a wide range because of varying probabilities of accidents and dispersion conditions.** *Therefore, the CCDFs are presented as logarithmic plots in which numbers varying* over a large range can be conveniently shown on a graph scaled in powers of 10. For example, a consequence magnitude of 10^6 means a consequence magnitude of one million (1 followed by six zeroes); a probability of 10^{-6} per reactor-year means a chance of 1 in one million or one millionth (0.000001) per reactor-year. All release categories shown in Table 5.11c contribute to the results; the consequences from each are weighted by its associated probability (Table 5.11d). For these calculations, the Evac Reloc mode of offsite emergency response was assumed *for accidents initiated by causes internal to the plant, by fires and by low to* moderately severe earthquakes; and Late Reloc mode of offsite emergency response was assumed for accidents initiated by very severe regional earthquakes (see Table 5.11f).

Figure 5.4b shows the probability distribution for the number of persons who might receive whole-body doses equal to or greater than 25 rems, total bone marrow doses equal to or greater than 200 rems, and thyroid doses equal to or greater than 300 rems from early exposure;*** all on a per reactor-year basis. The 200-rem total bone marrow dose figure corresponds, approximately, to a threshold value for which hospitalization would be indicated for the treatment of radiation injury. The 25-rem whole-body dose (which has been identified earlier as the lower limit for a clinically observable physiological effect in nearly all people) and the 300-rem thyroid dose figures correspond to the Commission's guideline values for reactor siting in 10 CFR 100.

Figure 5.4b shows in the left-hand portion that there are, approximately, 60 chances in 1 million (6×10^{-5}) per reactor-year that one or more persons may receive doses equal to or greater than any of the doses specified. The fact that the three curves run almost parallel in horizontal lines initially shows that if one person were to receive such doses, the chances are about the same that up to 10 would be so exposed. The chances of larger numbers of persons being exposed at those levels are seen to be considerably smaller. For example, the chances are less than 1 in 1 million (10^{-6}) that 10,000 or more people might receive doses of 200 rems or greater. A majority of the exposures reflected in this figure would be expected to occur to persons within a 40-km (25-mile) radius of the plant. Virtually all would occur within a 160-km (100-mile) radius.

Figure 5.4c shows the probability distribution for the total population exposure in person-rems; that is, the probability per reactor-year that the total population exposure will equal or exceed the values given. Most of the population

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*ry in the plots means reactor-year.

**See (7) below for further discussion of areas of uncertainty.

***Early exposure to an individual includes external doses from the radioactive cloud and the contaminated ground, and the dose from internally deposited radionuclides from inhalation of contaminated air during the cloud passage. Other pathways of exposures are excluded.

exposure up to 100 million person-rems would occur within 80-km (50 miles) but very severe releases would result in exposure to persons beyond the 80-km (50-mile) range, as shown.

For perspective, population doses shown in Figure 5.4c may be compared with the annual average dose to the population within 80 km (50 miles) of the Limerick site resulting from natural background radiation of about 800,000 person-rems, and to the anticipated annual population dose to the general public (total U.S.) from normal plant operation of about 80 person-rems (both units, excluding plant workers) (Appendix D of the environmental statement, Tables D.7 and D.9).

Figure 5.4d represents the statistical relationship between population exposure and the induction of fatal cancers that might appear over a period of many years following exposure. The impacts on the total population and the population within 80 km (50 miles) are shown separately. Further, the fatal latent cancer estimates have been subdivided into those attributable to exposures of the thyroid and all other organs. The majority of latent cancer (including thyroid) fatalities would occur within 80 km (50 miles) of the plant.

Figure 5.4e shows probability distributions of early fatalities. Two curves are shown representing benefits of two types of medical treatment (supportive and minimal; see Appendix J of this supplement and Appendix F of Appendix VI of WASH-1400) that would likely be given to individuals receiving excessive doses to the total bone narrow from early exposure. One curve shows the results considering the benefit of the supportive medical treatment. The early fatalities with supportive medical treatment are predicted to be essentially all within 32 km (20 miles) of the site. The other curve shows the results including the benefit of minimal medical treatment. The early fatalities with minimal medical treatments are predicted to be essentially all within 80 km (50 miles) of the site. As discussed in Appendix J, because it is conceivable that for very severe but low probability accidents, some of the people requiring supportive medical treatment may not actually receive it, the likely probability distribution of the early fatalities would be between the two curves shown in Figure 5.4e.

Figure 5.4f shows the probability distributions of early injuries that may result from acute radiation exposure. The cases of early injuries are predicted to be all within 160 km (100 miles) of the site.

An additional potential pathway for doses resulting from atmospheric release is from fallout onto open bodies of water. This pathway has been investigated in the NRC analysis of the Fermi Unit 2 plant, which is located on Lake Erie, and for which appreciable fractions of radionuclides in the plume could be deposited in the Great Lakes (NUREG-0769). It was found that for the Fermi site, the indicated individual and societal doses from this pathway were smaller than the interdicted doses from other pathways. Further, the individual and societal liquid pathway doses could be substantially eliminated by the interdiction of the aquatic food pathway in a manner comparable to interdiction of the terrestrial food pathway in the present analysis. Because Limerick is not on a large surface water body, the fraction of radioactive material that could fall out in nearby rivers, streams, or lakes would be correspondingly reduced. The staff has also considered fallout onto and runoff and leaching into water bodies in connection with a study of severe accidents at the Indian Point reactors in southeastern New York (Written staff testimony on Commission Question 1, Section III.D by Richard Codell on Liquid Pathway Considerations for the Indian Point ASLB Special Hearing, June 1982-April 1983). In this study empirical models were developed based upon considerations of radionuclide data collected in the New York City water supply system as a result of fallout from atmospheric weapons tests. As with the Fermi study, the Indian Point evaluation indicated that the uninterdicted risks from this pathway were fractions of the interdicted risks from other pathways. Further, if interdicted in a manner similar to interdiction assumed for other pathways, the liquid pathway risk from fallout would be a very small fraction of the risks from other pathways. Considering the LGS and the regional meteorology and hydrology, the staff sees nothing to indicate that the liquid pathway contribution to the total accident risk would be significantly greater than found for Fermi 2 and Indian Point. This water pathway would be of small importance compared to the results presented here for fallout onto land.

(4) Economic and Societal Impacts

As noted in Section 5.9.4.2, the various measures for avoiding adverse health effects, including those resulting from residual radioactive contamination in the environment, are possible consequential impacts of severe accidents. Calculations of the probabilities and magnitudes of such impacts for Limerick station and environs also have been made. (NUREG-0340 describes the model used.) Unlike the radiation exposure and health effect impacts discussed above, impacts associated with avoiding adverse health effects are more readily transformed into economic impacts.

The results are shown as the probability distribution for cost of offsite mitigating actions in Figure 5.4g and are included in the impact summary Table 5.11g. The factors contributing to these estimated costs include the following:

- evacuation costs
- value of crops contaminated and condemned
- value of milk contaminated and condemned
- costs of decontamination of property where practical
- indirect costs resulting from the loss of use of property and incomes derived therefrom

The last-named costs would derive from the necessity for interdiction to prevent the use of property until it is either free of contamination or can be economically decontaminated.

Figure 5.4g shows that at the extreme end of the accident spectrum these costs could exceed tens of billions of dollars, but that the probability that this would occur is exceedingly small (less than one chance in 10 million per reactor-year).

Additional economic impacts that can be monetized include costs of related health effects, cost of regional industrial impacts, costs of decontamination of the facility itself, and the costs of replacement power. Probability distributions for these impacts have not been calculated, but they are included in the discussion of risk considerations in Section 5.9.4.5(6) below.

As an additional impact of environmental contamination, Figure 5.4h shows the probability distribution of severely contaminated land area in square meters (about 2.6 million square meters equals 1 square mile) that would not be returned to use by decontamination, because decontamination procedures would not be very effective. Such areas would be marked for long-term interdiction (more than 30 years). At the extreme end of the accident spectrum, Figure 5.4h shows that such areas could be as large as several hundreds of square miles, but the probability that this could occur is extremely small (less than 1 chance in 10 million per reactor-year). This impact is also included in Table 5.11g.

The geographical extent of the kinds of impacts discussed above, as well as many other types of impacts, is a function of several factors. For example, the dispersion conditions and wind direction following a reactor accident, the type of accident, and the magnitude of the release of radioactive material are all important in determining the geographical extent of such impacts. Because of these large inherent uncertainties, the values presented herein are mean values of the important types of risk based upon the methodology employed in the accident consequence model (NUREG-0340) and do not indicate specific geographical areas.

(5) Releases to Groundwater

A groundwater pathway for radiation exposure to the public and environmental contamination that would be unique for severe reactor accidents was identified in Section 5.9.4.2(2) above. Consideration has been given to potential environmental impacts of this pathway for the Limerick station. The penetration of the basemat of the containment building can release molten core debris to the strata beneath the plant. The soluble radionuclides in the debris can be leached and transported with groundwater to downgradient domestic wells used for drinking water or the surface water bodies used for drinking water, aquatic food, and recreation. Releases of radioactivity to the groundwater underlying the site could also occur via depressurization of the containment atmosphere and releases of radioactive ECCS and suppression pool water through the failed containment.

An analysis of the potential consequences of a liquid pathway release of radioactivity for generic sites was presented in the "Liquid Pathway Generic Study" (LPGS) (NUREG-0440). The LPGS compares the risk of accidents involving the liquid pathway (drinking water, irrigation, aquatic food, swimming, and shoreline usage) for four conventional, generic, land-based nuclear plants and for a floating nuclear plant for which the nuclear reactor would be mounted on a barge and moored in a water body. Parameters for each generic land-based site were chosen to represent averages for a wide range of real sites and were thus "typical", but represented no real sites in particular. The discussion in this section is a summary of an analysis performed to compare the liquid pathway consequences of a postulated accident at the Limerick site with that of the generic small-river land-based site considered in the LPGS. The comparison is made on the basis of population doses from drinking contaminated water, eating contaminated fish, and such shoreline uses as recreation. The parameters that were evaluated include the amounts and rate of release of radioactive materials to the ground, ground water travel time, sorption on geological media, surface water transport, drinking water usage, aquatic food consumption, and recreation area usage.

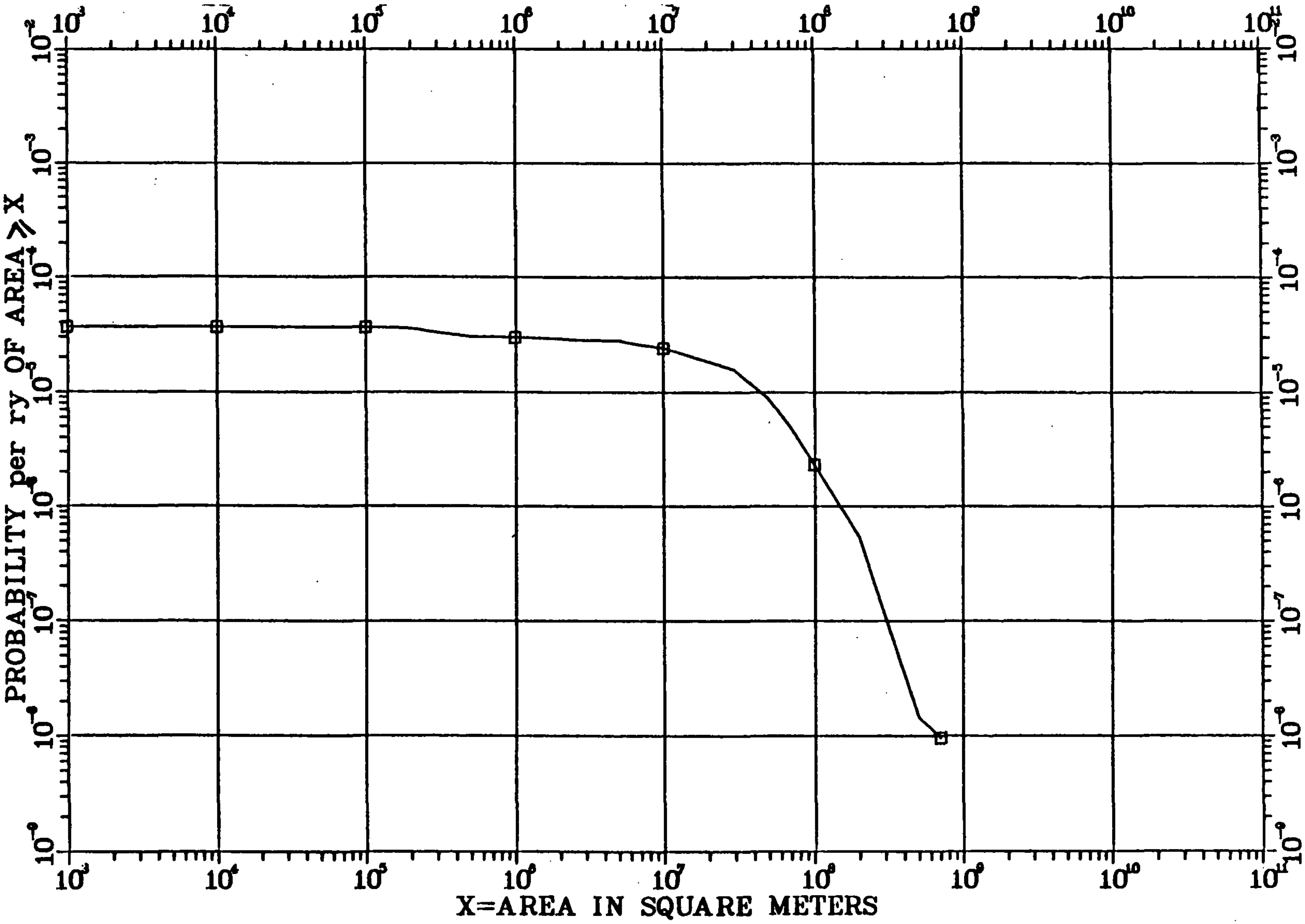

Figure 5.4h Probability distribution of land area interdiction

NOTE: See Section 5.9.4.5(7) for discussion of uncertainties.

All of the reactors considered in the LPGS were Westinghouse pressurized water reactors (PWRs) with ice condenser containments. There are likely to be significantly different mechanisms and probabilities of releases of radioactivity for the Limerick boiling water reactor (BWR). The staff is not aware of any studies which indicate the probabilities or magnitudes of liquid releases for BWRs. The source term used for Limerick in this comparison is assumed to be equal to that used in the LPGS.

Doses to individuals and populations were calculated in the LPGS without consideration of interdiction methods such as isolating the contaminated groundwater or denying use of the water. In the event of surface water contamination, alternative sources of water for drinking, irrigation, and industrial uses would be expected to be found, if necessary. Commercial and sports fishing, as well as many other related activities, could be restricted. The consequences would, therefore, be largely economic and social rather than radiological. In any event, the individual and population doses for the liquid pathway range from fractions to very small fractions of those that can arise from the airborne pathways.

The Limerick site is about 244 meters (800 feet) from and 33.5 meters (110 feet) above the Schuylkill River. The aquifer underlying the site is composed of red shale, sandstone, and siltstone. Most of the groundwater movement in the aquifer follows secondary openings that have developed following the deposition of the beds. The most important openings are nearly vertical joint planes; they cross each other at various angles throughout the beds. Where these joints are present, they provide an interconnected series of channels through which groundwater can flow, giving the material a low to moderate permeability.

The weathered upper bedrock in the power block area has been removed and the small fracture zones in the remaining rock have been filled with concrete. Should a core melt accident occur at the Limerick site and the leached radionuclides find a path through the concrete basemat, the tight bedrock beneath the basemat would tend to confine the effluent and greatly limit its transport downgradient. For the purposes of this analysis, however, the radioactive effluent was conservatively assumed to travel immediately through the underlying rock and move downgradient toward the river.

The applicant performed an analysis of the liquid pathway release following a postulated core melt accident and determined a groundwater travel time of 3.28 years from the reactor building to the Schuylkill River The groundwater travel time calculated for the LPGS generic site was 0.61 years.

The staff has evaluated the applicant's groundwater travel time calculation and the data used to choose the pertinent parameters and considers the applicant's analyses to be conservative. The average bedrock permeability, estimated from site permeability tests, is 65 m (214 feet) per year, and the effective porosity is estimated to be 0.05. The groundwater gradient likely to exist after plant construction is estimated to be no greater than 0.025, based on well hydrographs at the site. From these values, the staff estimates a groundwater travel time of 7.5 years for the 244 meters to the river.

It was demonstrated in the LPGS that for holdup times on the order of years, virtually all the liquid pathway population dose results from Sr-90 and Cs-137.

Therefore, only these two radionuclides are considered in the remainder of this analysis.

The radionuclides Sr-90 and Cs-137 usually move much slower than groundwater because of the effects of sorption (ion-exchange) on the geologic media. However, most of the measured values of the retardation effects of sorption are applicable only to soil or pulverized rock. There is only limited data available on retardation in fractured geologic media. At the Limerick site, however, the fractures in the siltstone and sandstone are partially filled with calcite, sand, and clay. Hence, part of the flow path would be through porous media, and ion exchange can be expected to retard the movement of radionuclides to the Schuylkill River. Based on measured retardation related distribution coefficients (Kd) for similar rock types and soil (Isherwood, 1981), a Kd of 2 was selected for Sr-90 and a Kd of 20 for Cs-137. Both Kd values selected are on the low side of representative values and are, therefore, considered to be conservative. A total porosity of 25% was selected as representative of the fractured and filled media through which the radioactive effluent would travel. From these values, retardation coefficients of 20 for Sr-90 and 193 for Cs-137 were determined as being reasonably conservative for the transport media. The calculated radionuclide travel time is then 150 years for Sr-90 and 1447.5 years for Cs-137. The radionuclide travel times for Sr-90 and Cs-137 in the LPGS are 5.7 years and 51 years, respectively. As a result of radioactive decay, the estimated amount of Sr-90 entering the Schuylkill River would be reduced to about 3% of the amount determined in the LPGS. The amount of Cs-137 would be about 14 orders of magnitude less than that in the LPGS, and its contribution to population dose via the various pathways (drinking water, fish consumption, and recreation activities) need not be considered further.

The primary pathway for Sr-90 to humans is through drinking water. Comparison of drinking water population doses will be based upon the ratio of population served to river flow, which takes into account the effects of dilution. Downstream of the Limerick site, there are approximately 1.9 million people using the Schuylkill River as a drinking water supply. The average flow in Schuylkill River is about 1900 ft^3/sec resulting in a population to flow ratio of 1000 people/ft^3/sec. The corresponding ratio in the LPGS for a small river site is about 32 people/ft^3sec. Hence, for a similar release to a river, the total drinking water dose at Limerick without a change in drinking water supply, would be about 30 times worse. However, since the concentration of Sr-90 entering the water would be only 3% of that of the LPGS, the total drinking water dose is roughly equivalent to that determined in the LPGS. The staff concludes that population dose as a result of the liquid pathway contribution at the Limerick site would be about the same as that from the generic site.

The staff recognizes that, because of the differences in design of the Limerick reactor as compared to the reactor design analyzed in the LPGS, a different inventory of radionuclides could be released following a core melt accident and postulated breach of the basemat. This uncertainty, along with uncertainties in the amount of radionuclides that could be released, could result in a different dose comparison than the one presented. However, the staff also considers the potential for a release through the basemat at the Limerick site following a core melt accident to be significantly less than that for the design considered in the LPGS. Therefore, the total risk from the liquid pathway is still estimated to be less than or about the same order as that in the LPGS.

In conclusion, Limerick should be considered about equal in regard to risk from the liquid pathway (groundwater) in comparison to other land-based sites. In addition, the long groundwater travel time ensures that mitigation measures such as slurry walls, grouting, dewatering, and other measures can be completed in time to protect downstream drinking water and fisheries. A comprehensive discussion of accident mitigation measures has been presented by V. A. Harris (Harris, 1982).

(6) Risk Considerations

The foregoing discussions have dealt with both the frequency (or likelihood of occurrence) of accidents and their impacts (or consequences). Because the ranges of both factors are quite broad and uncertain (see (7) below), it also is useful to combine them to obtain average measures of environmental risks. Such averages can be particularly instructive as an aid to the comparison of radiological risks associated with accident releases with risks associated with normal operational releases and with other forms of risks.

A common way in which this combination of factors is used to estimate risk is to multiply probabilities by the consequences. The resultant risk is then expressed as a measure of consequences per unit of time. Such a quantification of risk does not mean that there is universal agreement that peoples' attitudes about risks, or what constitutes an acceptable risk, can or should be governed solely by such a measure. However, it can be a contributing factor to a risk judgment, although not necessarily a decisive factor.

Table 5.11h shows average values of societal risk estimates associated with population dose, early fatalities with two types of medical treatment (minimal and supportive), early injuries, latent cancer fatalities, costs for evacuation and other protective actions, and land area for long-term interdiction. These average values are obtained by summing the probabilities multiplied by the consequences over the entire range of the distributions. Because the probabilities are on a per-reactor-year basis, the averages shown also are on a per-reactor-year basis.

Incremental risks per reactor-year of early fatality (with two types of medical treatment) and latent cancer fatality associated with spatial intervals up to 50 miles (80 km) from the Limerick reactors are shown in Appendix L.

The population exposures and latent cancer fatality risks may be compared with those from normal operation shown in Appendix D and Section 5.9.3.2 of this statement. The comparison (excluding exposure to station personnel) shows that the accident risks are up to 30 times higher. For a different perspective, the latent cancer (including thyroid) fatality risks of 3×10^{-4} persons per reactor-year within 1 mile (1.6 km) of the site exclusion area boundary (EAB) (based on data in Table L.4 in Appendix L) and 5×10^{-2} persons per reactor-year within the 50-mile (80-km) region (from Table 5.11h) may be compared with such risks from causes other than reactor accidents. Approximately 3000 persons are projected to live within 1 mile (1.6 km) from the EAB and 7 million persons are projected to live within the 50-mile (80-km) region in the year 2000. The background cancer mortality rate is 1.9×10^{-3} cancer fatality per person per year

Table 5.11h Estimated values of societal risks from severe accidents, per reactor-year

Consequence type	Estimated risk within the 50-mile region	Estimated risk within the entire region
1. Early fatalities with Supportive medical treatment (persons)	5(-3)*	5(-3)
2. Early fatalities with minimal medical treatment (persons)	8(-3)	8(-3)
3. Early injuries (persons)	2(-2)	2(-2)
4. Latent cancer fatalities (excluding thyroid) (persons)	4(-2)	7(-2)
5. Latent thyroid cancer fatalities (persons)	1(-2)	1(-2)
6. Total person-rems	7(2)	1(3)
7a. Cost of offsite mitigation measures (1980 $)	5(4)	5(4)
7b. Regional industrial impact costs (1980 $)		5(4)***
7c. Plant costs (1980 $)	1(5)	
8. Land area for long-term interdiction (m^2)**	1(3)	1(3)

*5(-3) = 5×10^{-3} = .005
**About 2.6 million m^2 equals to 1 mi^2.
***Excludes costs of crop and milk interdiction, which are included in 7a.

NOTE: Please see Section 5.9.4.5(7) for discussion of uncertainties. Estimated numbers were rounded to one significant digit only for the purpose of this table.

in the U.S (American Cancer Society, 1981). Therefore, at this rate, about 6 background cancer fatalities per year are expected in the population within 1 mile (1.6 km) of the EAB, and 10,000 background cancer fatalities in the population within the 50-mile (80-km) region in the year 2000. Thus, the risk of cancer fatality from reactor accidents at Limerick is small compared to the risk of normal occurrence of such fatality.

The ratio of latent cancer fatality risk from reactor accidents at Limerick to the population living within 50 miles of the plant in the year 2000 to the cancer fatality risk in the same population from all other causes is 5×10^{-6} (5×10^{-2}/10,000) on a per reactor-unit basis.

There are no early fatality, early injury, long-term land interdiction, or economic risks associated with protective actions and decontamination for normal releases; but these risks can be associated with large accidental releases. For perspective and understanding of the meaning of the early fatality risk of 5×10^{-3} persons per reactor-year with supportive medical treatment and 8×10^{-3} persons per reactor-year with minimal medical treatment (from Table 5.11h), the staff notes that occurrences of early fatalities with supportive and minimal medical treatments would be contained, approximately, within the 20-mile (32-km) and 50-mile (80-km) regions, respectively. The number of persons projected to live within these regions in the year 2000 are 0.8 million and 7 million, respectively. The background risk for the average individual in the U.S. is 5×10^{-4} accidental death per year (NUREG/CR-1916). Therefore, the expected number of non-Limerick accidental fatalities per year within the 20-mile (32-km) and 50-mile (80-km) regions are 400 and 4000, respectively, in the year 2000. Thus, the risk of early fatality with supportive or minimal medical treatment from reactor accidents at Limerick is extremely small compared with that from non-Limerick accidents. For an added perspective, the risk of early fatality within 1 mile (1.6 km) of the exclusion area boundary (EAB) from reactor accidents may be compared with early fatality risk from nonnuclear accidents in the same region. From Tables L.2 and L.3 in Appendix L, the Limerick risks of early fatality with supportive or minimal medical treatments are 5×10^{-4} persons per reactor-year and 6×10^{-4} persons per reactor-year, respectively, in this region. At the average rate of 5×10^{-4} nonnuclear accidental death per individual per year in the U.S., the number of nonnuclear accidental fatalities in the population of 3000 projected to live within 1 mile (1.6 km) from the EAB in the year 2000 would be 2 per year. This also shows that the early fatality risk from reactor accidents at Limerick is expected to be small compared with risk of nonnuclear accidental deaths.

The ratio of (1) risk of early fatality with minimal medical treatment from reactor accidents at Limerick to an average individual living within a mile of the site exclusion area boundary to (2) the risk to the same individual of accidental death from all other causes, is 3×10^{-4} ($6 \times 10^{-4}/3000 \div 2/3000$) on a per reactor-unit basis.

To provide a reasonable bound to the role of evacuation in risk estimates from the release categories not initiated by severe earthquakes, as well as to assess the sensitivity of risks from these release categories with respect to uncertainties in executing an evacuation, an analysis of these release categories was made by assuming the Early Reloc mode of offsite emergency response (see Table 5.11f). Results of the analysis are provided in Appendix M. These results, when combined with those previously calculated for the release categories initiated by severe eathquakes, show only slight increases in the risks of latent cancer and early fatalities and also corroborate the preceding conclusions that these risks from Limerick reactor accidents are small compared with the background risks from nonnuclear causes.

Figure 5.4i shows the calculated risk of whole-body dose to an individual from early exposure as a function of the downwind distance from the plant. The values are on a per-reactor-year basis and all release categories contributed to the dose, weighted by their associated probabilities. For purposes of comparison the risk of receiving a whole body dose of 99 mrems per year from

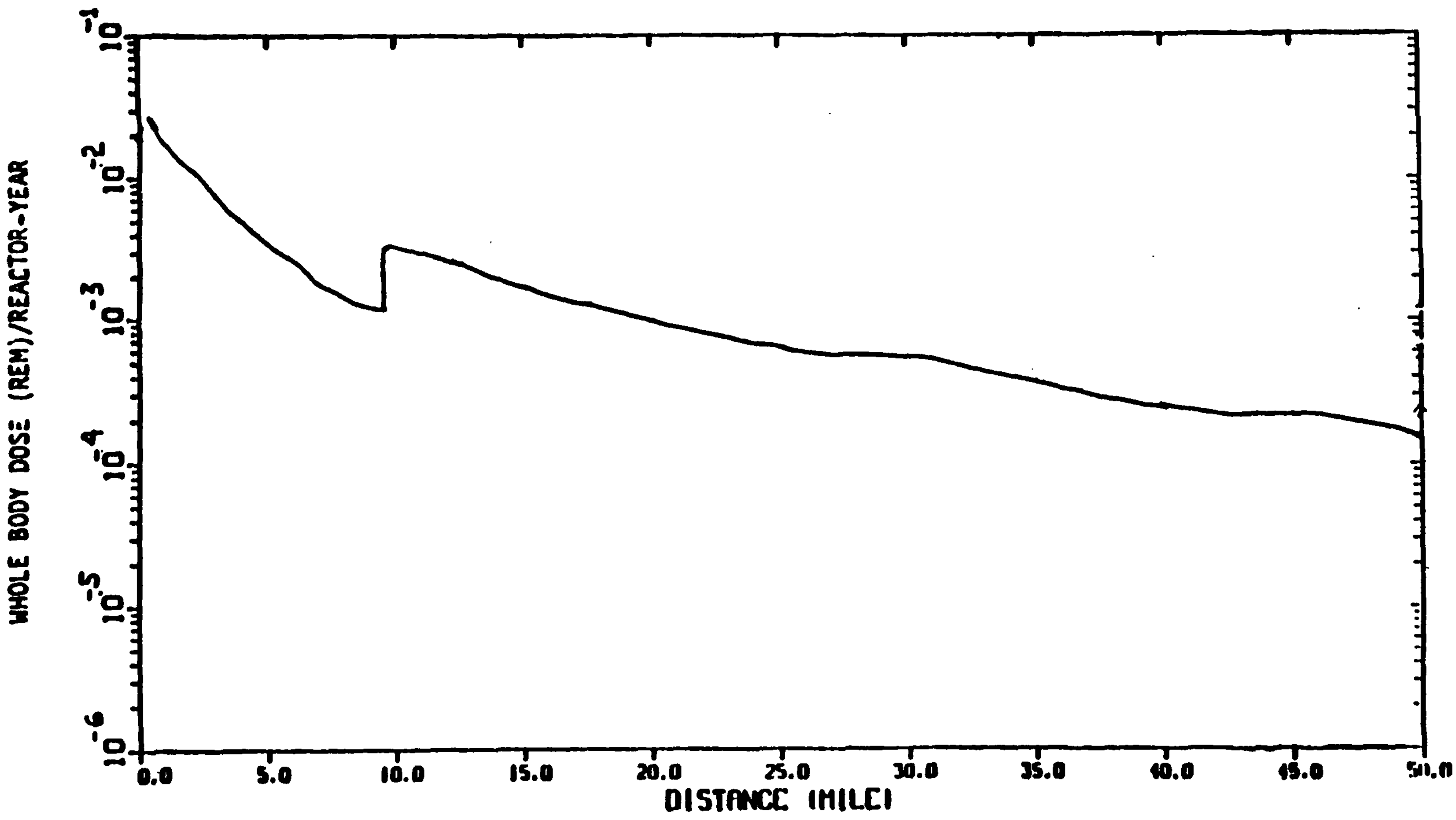

Figure 5.4i Risk of downwind individual dose versus distance

NOTE: Please see Section 5.9.4.5(7) for discussion of uncertainties

natural background is a virtual certainty for any individual living in the Limerick site region (see Table D.7 in Appendix D).

Figures 5.4j, 5.4k, and 5.4l, respectively, display risk to an individual of early fatality, early injury, and latent cancer fatality, all from early exposure, as functions of distance from the Limerick reactors and on a per-reactor-year basis. The curves in these figures were generated without regard to the differences in the likelihood of wind blowing in different directions (the staff used 16 direction sectors of the compass). To obtain risk curves for a specific direction (1 out of the 16), all values on the curves along the vertical axis must be multiplied by 16P, where P is the annual average probability of the wind blowing toward the direction of interest. The values of P for the Limerick site derived from 1976 meteorological data are shown in Table 5.11e. For comparison to early fatality risk to an individual from Limerick reactor accidents, the following nonnuclear risks, per year, of accidental fatality to an individual living in the United States may be noted (National Research Council, 1979, p. 577): automobile accident 2.2×10^{-4}, falls 7.7×10^{-5}, drowning 3.1×10^{-5}, burning 2.9×10^{-5}, and firearms 1.2×10^{-5}. For comparison to the estimated latent cancer fatality risk to an individual from the Limerick reactor accidents, it should be noted that the risk of cancer fatality to an individual in the U.S. from nonnuclear causes is 1.9×10^{-3} per year (American Cancer Society, 1981).

The economic risk associated with evacuation and other protective actions could be compared with property damage costs associated with alternative energy generation technologies. The use of fossil fuels, coal, or oil, for example, would emit substantial quantities of sulfur dioxide and nitrogen oxides into the atmosphere and, among other things, lead to environmental and ecological damage through the phenomenon of acid rain (National Research Council, 1979, pp. 559-560). In the judgment of the staff, this effect has not been sufficiently quantified to draw a useful comparison at this time.

The staff has also considered the health care costs resulting from hypothetical accidents in a generic model developed by the Pacific Northwest Laboratory (Nieves, 1982). Based upon this generic model, the staff concludes that such costs may be a fraction of the offsite costs evaluated herein, but that the model is not sufficiently constituted for application to a specific reactor site.

A severe accident that requires the interdiction and/or decontamination of land areas is likely to force numerous businesses to temporarily or permanently close. These closures would have additional economic effects beyond the contaminated areas through the disruption of regional markets and sources of supplies. Estimates of these risks were made using: (1) the RSS consequence model (Appendix VI, WASH-1400) and (2) the regional input-output modeling system (RIMS II), developed by the Bureau of Economic Analysis (BEA).

The industrial impact model developed by BEA is based on contamination levels of a physically affected area defined by the RSS consequence model. Contamination levels define an interdicted area immediately surrounding the plant, followed by an area of decontamination, an area of crop interdiction, and finally an area of milk interdiction.

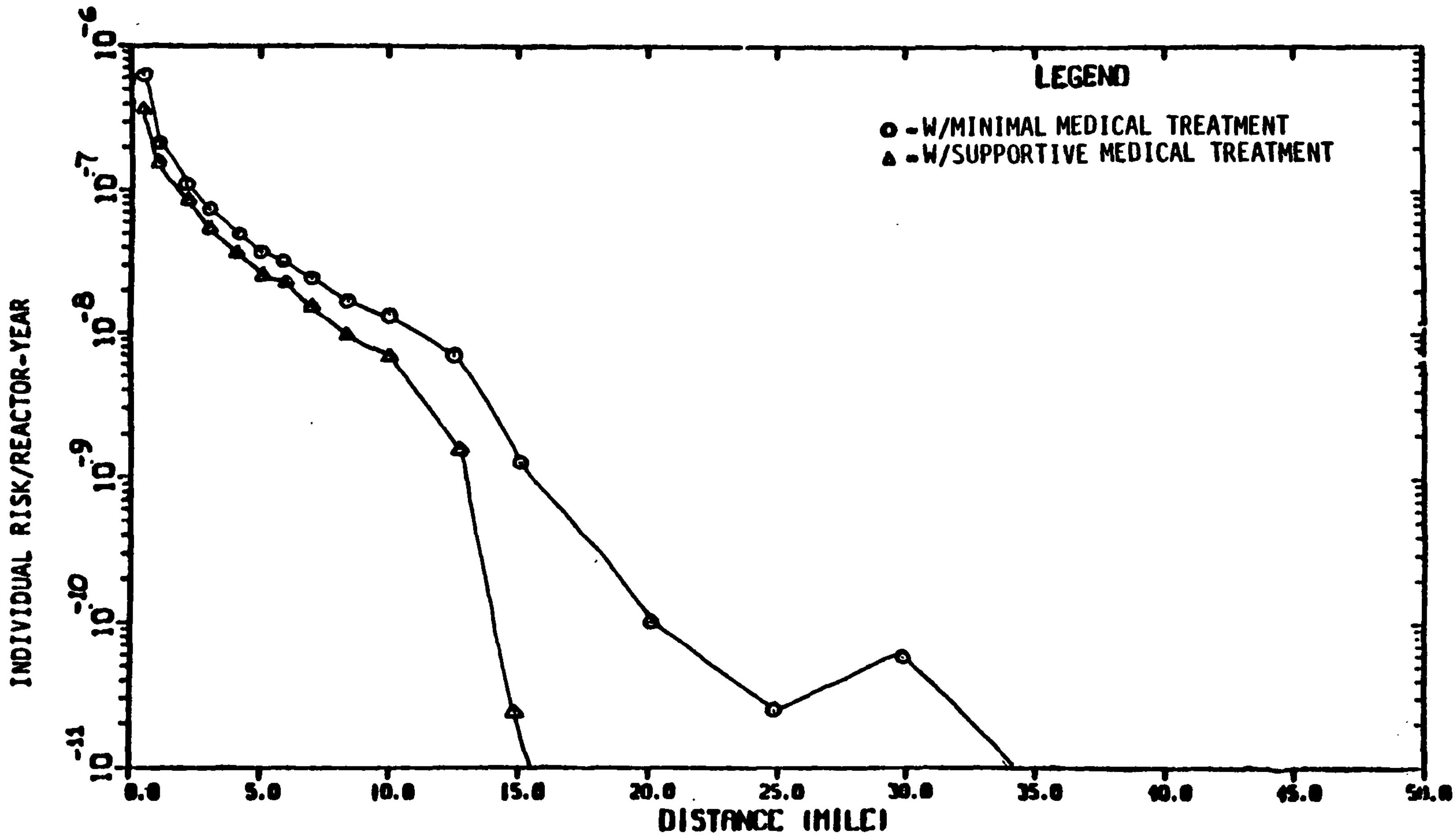

Figure 5.4j Individual risk of early fatality versus distance

NOTE: Please see Section 5.9.4.5(7) for discussion of uncertainties

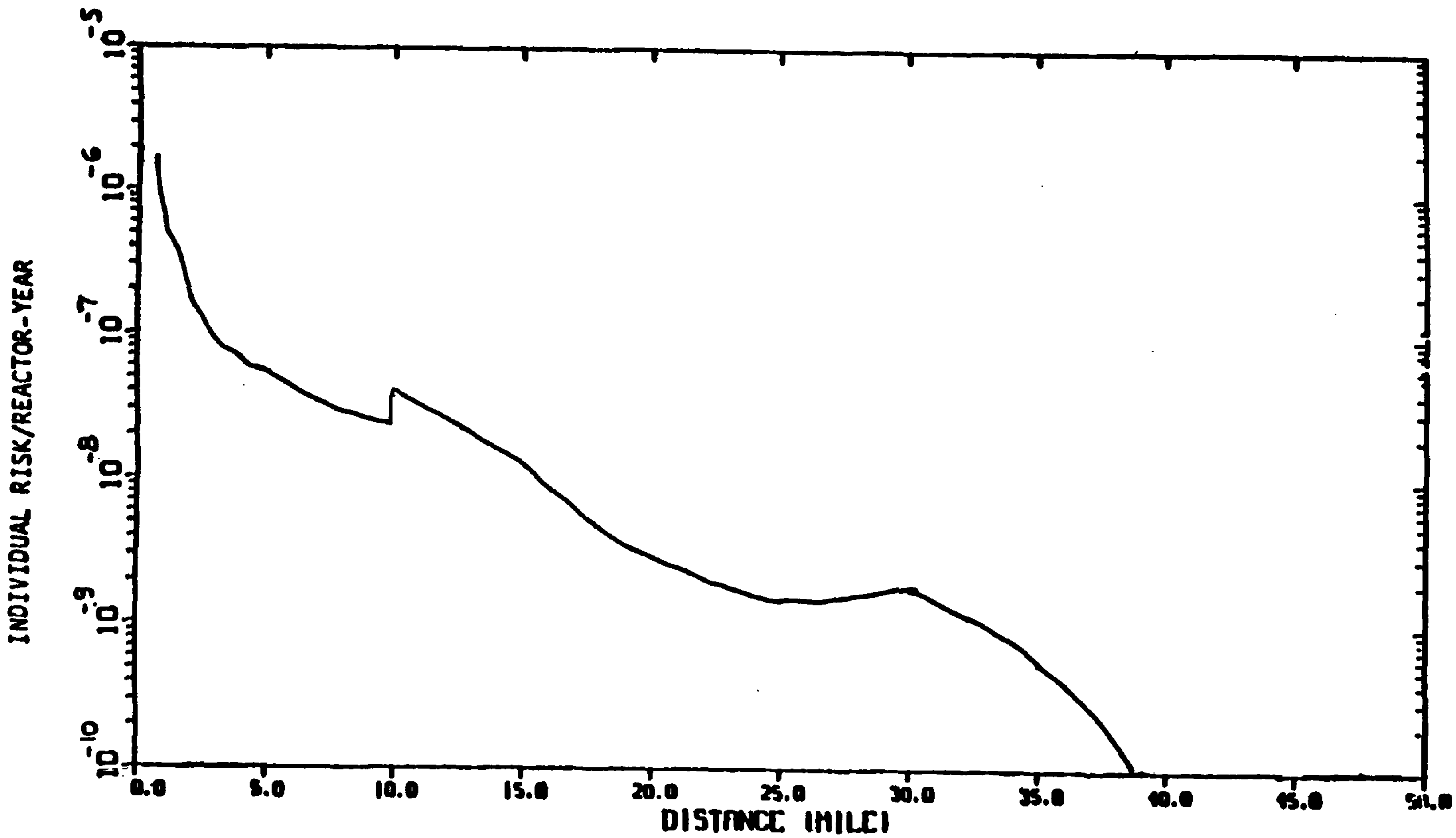

Figure 5.4k Individual risk of early injury versus distance

NOTE: Please see Section 5.9.4.5(7) for discussion of uncertainties

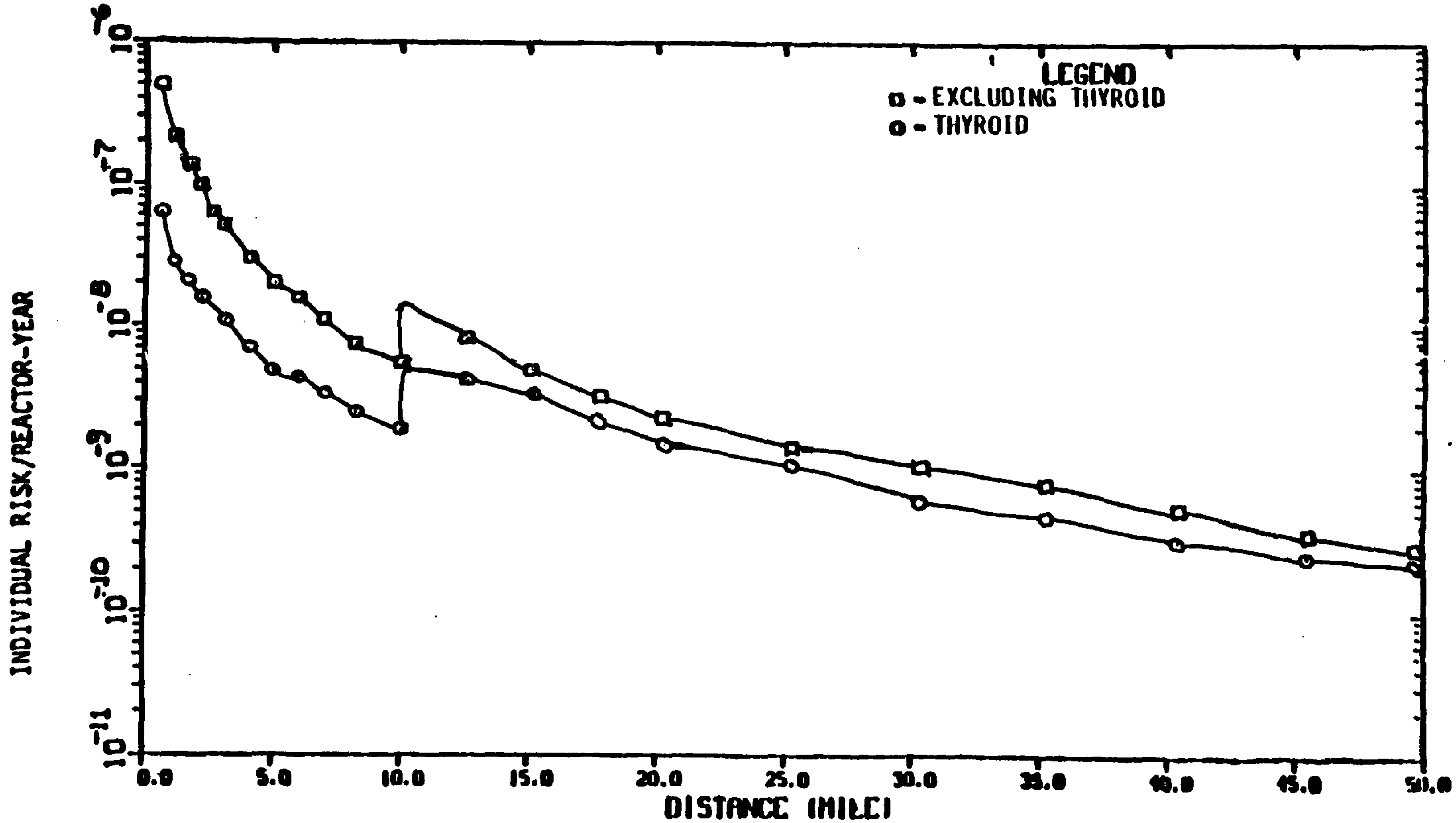

Figure 5.41 Individual risk of latent cancer fatality versus distance

NOTE: Please see Section 5.9.4.5(7) for discussion of uncertainties

Specific assumptions used in the analysis are

(1) In the interdicted area, all industries would lose total production for more than a year.

(2) In the decontamination zone, there would be a 3-month loss in nonagricultural output; a 1-year loss in all crop output (except there would be no loss in greenhouse, nursery, and forestry output); a 3-month loss in dairy output; and a 6-month loss in livestock and poultry output.

(3) In the crop interdiction area, there would be no loss in nonagricultural output; a one-year loss in agricultural output (except there would be no loss in greenhouse, nursery, and forestry output); no loss in livestock and poultry output; and a 2-month loss of dairy output.

(4) In the milk interdiction zone, there would be only a 2-month loss in dairy output.

The estimates of industrial impacts are made for an economic study area that consists of a physically affected area and a physically unaffected area. An accident that causes an adverse impact in the physically affected area (for example, the loss of agricultural output) could also adversely affect output in the physically unaffected area (for example, food processing). In addition to the direct impacts in the physically affected area, the following additional impacts could occur in the physically unaffected area:

(1) decreased demand (in the physically affected area) for output produced in the physically unaffected area

(2) decreased availability of production inputs purchased from the physically affected area

Only the impacts occuring during the first year following an accident are considered. The longer term consequences are not considered because they will vary widely depending on the level and nature of efforts to mitigate the accident consequences and to decontaminate the physically affected areas.

The estimates assume no compensating effects, such as the use of unused capacity in the physically unaffected area to offset the initial lost production in the physically affected area or income payments to individuals displaced from their jobs that would enable them to maintain their spending habits. These compensating effects would reduce the industrial impacts. Realistically, these compensating effects would occur over a lengthy period. The estimates using no compensating effects are the best measures of first year economic impacts.

The output loss risk can be estimated by mutiplying the probabilities of the release categories representative of those in Table 5.11c by the probability of the wind blowing in various directions and the associated consequences. The overall risk associated with these release categories was then estimated as the sum of the individual products. The estimated overall risk values using output losses as the measure of accident consequences, expressed in a per reactor-year basis, is $50,000 (1980 dollars) per reactor-year. This includes $2000 as the cost of crop and milk interdictions calculated in CRAC runs for consequence analysis. The corresponding expected employment loss is between two and three jobs per reactor-year. Half of the total risk per reactor-year is accounted for by the cases of wind blowing toward the east-southeast. The risk is least severe with the wind blowing toward the east-southwest. Because of the economic mix of the entire region, the composition of impacts consists of 85% nonagricultural impacts, 4% agricultural impacts, and 11% indirect impacts of decreased exports and supply constraints.

There are other economic impacts and risks that can be monetized but that are not included in the cost calculations discussed earlier. These are accident impacts on the facility itself that result in added costs to the public (ratepayers, taxpayers, and/or shareholders). These costs would be for decontamination and repair or replacement of the facility, and replacement power. Experience with such costs is currently being accumulated as a result of the Three Mile Island accident. If an accident occurs during the first full year of Limerick Unit 1 operation (1985), the economic penalty associated with the initial year of the unit's operation is estimated at $1500 million for decontamination and restoration, including replacement of the damaged nuclear fuel. This is based on a conservative (high) 10% escalation of the $950 million cost in 1980 dollars estimated for Three Mile Island (EMD-81-106). Although insurance would cover $300 million or more of the $1500 million, the insurance is not credited against the $1500 million because the $300 million times the risk probability should theoretically balance the insurance premium. In addition, staff estimates additional fuel costs of $50 million (1985 dollars) for replacement power during each year Limerick Unit 1 was being restored. This estimate assumes conservatively (high cost) that two-thirds of the energy that would have been forthcoming from the unit (assuming 55% capacity factor) would be replaced by coal-fired generation and one-third by oil-fired generation. Assuming the nuclear unit does not operate for 8 years, the total additional replacement power costs would be approximately $400 million in 1985 dollars.

The probability of a core melt or severe reactor damage is assumed to be as high as 10^{-4} per reactor year (this accident probability is intended to account for all severe core damage accidents leading to large economic consequences for the owner, not just those leading to significant offsite consequences).

Multiplying the previously estimated costs of $1900 million for an accident to Limerick Unit 1 during the initial year of its operation by the above 10^{-4} probability results in an economic risk of approximately $190,000 (in 1985 dollars or $120,000 in 1980 dollars) applicable to Limerick Unit 1 during its first year of operation. This is also aproximately the economic risk (in 1985 dollars) to Limerick Unit 1 during the second and each subsequent year of its operation. Although nuclear units depreciate in value and may operate at reduced capacity factors so that the economic consequences of an accident become less as the units become older, this is conservatively (high cost) considered to be offset by a slightly higher escalation rate than discount rate.

The economic risk to Limerick Unit 2 (in 1985 dollars) is also approximately $190,000 (or $120,000 in 1980 dollars) during the first year and each subsequent year of operation because of the balancing effect of escalation and the present-worth discount factor.

(7) Uncertainties

The probabilistic risk assessment discussed above has been based mostly on the methodology in the RSS, which was published in 1975 (NUREG-75/014). Although substantial improvements have been made in various facets of the RSS methodology since this publication was issued, there are still large uncertainties in the results of the analysis presented above because of the uncertainties associated with the likelihoods of the accident sequences and containment failure modes leading to the release categories, the source terms for the release categories, and the estimates of environmental consequences.

Relatively more important contributors to uncertainties in the results presented in this supplement are as follows:

Probability of Occurrence of Accident

If the probability of a release category were to be changed by a certain factor, the probabilities of various types of consequences from that release category would also change exactly by the same factor. Thus, an order of magnitude uncertainty in the probability of a release category would result in an order of magnitude uncertainty in both societal and individual risks stemming from the release category. As in the RSS, there are substantial uncertainties in the probabilities of the release categories. This is due, in part, to difficulties associated with the quantification of human error and to inadequacies in (1) the data base on failure rates of individual plant components, and (2) the data base on external events and their effects on plant systems and components that are used to calculate the probabilities.

Severe earthquakes are one cause of accidents. Uncertainties in the estimates of probabilities of severe earthquake induced core melt sequences are judged to be very large because of (1) the relatively sparse data base on severe earthquakes in the eastern U.S. and (2) the unavailability of an acceptably precise and definite procedure to quantify seismically induced accident sequences. In LGS-SARA, the spectrum of probabilities of seismically induced core melt sequences varied over a wide range (several orders) of magnitudes. However, the mean (point or best estimate) probabilities of seismically induced core melt accident sequences used in the staff analysis (which essentially came from LGS-SARA) are within the range of probabilities developed in LGS-SARA, and are within a factor of about 6 of the upper end of the spectrum of probabilities in LGS-SARA. Thus, the point estimates of seismic probabilities used to evaluate risks are more representative of Limerick than WASH-1400 values, and consider the applicant's estimate of the range of seismic frequency uncertainty. The staff has concluded that the high and low values of the range should not be characterized as 95% and 5% limits, but rather as a representative range of the seismic sequence frequencies, which incorporates a large part (but not necessarily all) of the uncertainties with such events. This statement reflects the staff's view that the rigorous definition of seismic hazard and its uncertainty at low probabilities is beyond the state-of-the-art at this time and should be recognized as such. Different studies would not necessarily yield equivalent results. For example, an interium report to be published "Seismic Hazard Characterization of the Eastern U.S." of an ongoing study being carried out by Lawrence Livermore National Laboratory (LLNL) for the NRC shows seismic hazard calculations for the Limerick site which overlap, but are not necessarily coincident with, the range of seismic hazard assumed in LGS-SARA.

The median (50%) hazard calculated in the interim LLNL report is within, but near the high end of, the range of hazard curves utilized in LGS-SARA. Additional studies of seismic hazard in the eastern U.S. are being carried out by such groups as the Electric Power Research Institute. Given the highly judgmental nature of seismic hazard calculations, there is not reason to believe that these studies or the final LLNL report would not show differences in estimated seismic hazard and uncertainty between themselves and the LGS-SARA, particularly at the low probabilities being calculated for Limerick. The staff believes that only the use of a full range of seismic probabilities in risk analysis would be appropriate. However, to keep the risk analysis manageable, the staff has used the point estimates of probabilities of seismically induced release categories in the risk analysis, and has provided below a discussion of uncertainty in the risk estimates arising from the use of point estimates of probabilities.

Inspection of the results shown in Tables L-1a and b and M-1a and b indicates that with the use of the mean values of probabilities of the severe earthquake initiated release categories, these release categories contribute: (1) dominantly (about 4 to 30 times higher) to the risks of early fatality; (2) about equally to the risk of early injury; and (3) much less to the other types of risks--all compared to the contributions from the release categories initiated by causes other than severe earthquakes. If, instead of using the mean probabilities, the staff had used the values of probabilities of earthquake-initiated release categories from the high estimates, then: (1) the total risks of early fatality would be increased by a factor of about 6 (because the high estimates of probabilities of the earthquake-initiated release categories are about 6 times higher than the mean values); (2) the total risk of early injury would be increased by a factor of about 4; and (3) the other types of risks would be increased by factors of about 2. On the other hand, if the staff had used the low estimates of probabilities of the earthquake-initiated release categories (which are lower than the mean values by several orders of magnitudes), then the contributions to the risks from these release categories would be negligible compared to those from the release categories initiated by causes other than severe earthquakes. Therefore, use of the full range of probabilities of earthquake-initiated release categories would result in spreads in the staff's risk estimates; values of the risks would fall within ranges of about one-thirtieth to about 6 times the values depicted in Tables 5-11h, L-1a and b, and M-1a and b. We do not mean to imply that higher risk estimates are more appropriate than the median, mean or lower estimates. Indeed the most significant earthquake damage anywhere within the vicinity of the Limerick Site, in the two to three hundred years during which we have records, are fallen chimneys 50 kilometers away during an earthquake at Wilmington, Delaware in 1871 whose magnitude can be estimated to have been less than 5.0. We certainly cannot exclude from the range of reasonable assumptions the judgment that there essentially is no risk to the public resulting from earthquake-induced damage at the seismically-engineered nuclear power plant at Limerick during its operating life.

Overall, accident probabilities may be expressed in terms of the probability of core melt, and considered an important measure of the likelihood of environmental and human impacts from severe reactor accidents. To provide some perspective on the uncertainty in such estimates, Figure 5.4m compares the estimate of core melt probabilities and their uncertainties based on contemporary PRA-based estimates for several different reactors. Except for Limerick, the results presented on Figure 5.4m are taken directly from published PRAs without modification (Rowsome and Blond, 1982). The results for Limerick are based on staff contractor estimates for Limerick (NUREG-3028). The PRAs were not necessarily performed using consistent methodologies or assumptions, and some of the PRAs evaluate designs that have subsequently been altered. Caution should be exercised when using these results because there are very large uncertainties in these analyses. No attempt has been made to adjust the results to compensate for inconsistency of approach or methods. Therefore, the appropriateness of the comparison may be in question. However, all of the studies have analyzed, in roughly the same manner, the so-called "internally" initiated events.

Quantity and Chemical Form of Radioactivity Released

The models used in these calculations contain approximations to describe the physical behavior of the radionuclides which affects the transport within the reactor vessel and other plant structures and the amounts of release. This relates to the quantity and chemical form of each radionuclide species that would be released from a reactor unit during a particular accident sequence. Such releases would originate in the fuel and would be attenuated by physical and chemical processes in route to being released to the environment. Depending on the accident sequence, attenuation in the reactor vessel, the primary cooling system, the containment, and adjacent buildings would influence both the magnitude and chemical form of radioactive releases. The releases of radionuclides to the environment, called source terms, used in the staff analysis were determined using the RSS methodology applicable to a BWR of Peach Bottom design; therefore, the RSS methodology may not have been fully appropriate for the Limerick BWRs. Information available in NUREG-0772 and from the latest research activities sponsored by the Commission and the industry indicates that source terms used in the staff analysis cannot be much higher in the maximum, but could be substantially lower. Some lower source term values could be higher also, primarily because of the manner in which the source term was evaluated for early releases using the RSS methodology. The impact of lesser values of source terms would be substantially lower estimates of health effects, particularly early fatalities and injuries. The source terms resulting from the applicants PRA would, for example, yield significantly lower estimates of risk than those used by the staff in this report. The NRC staff anticipates better source term information at the end of 1984 when the staff's Accident Source Term Program Office and the American Physical Society complete their studies.

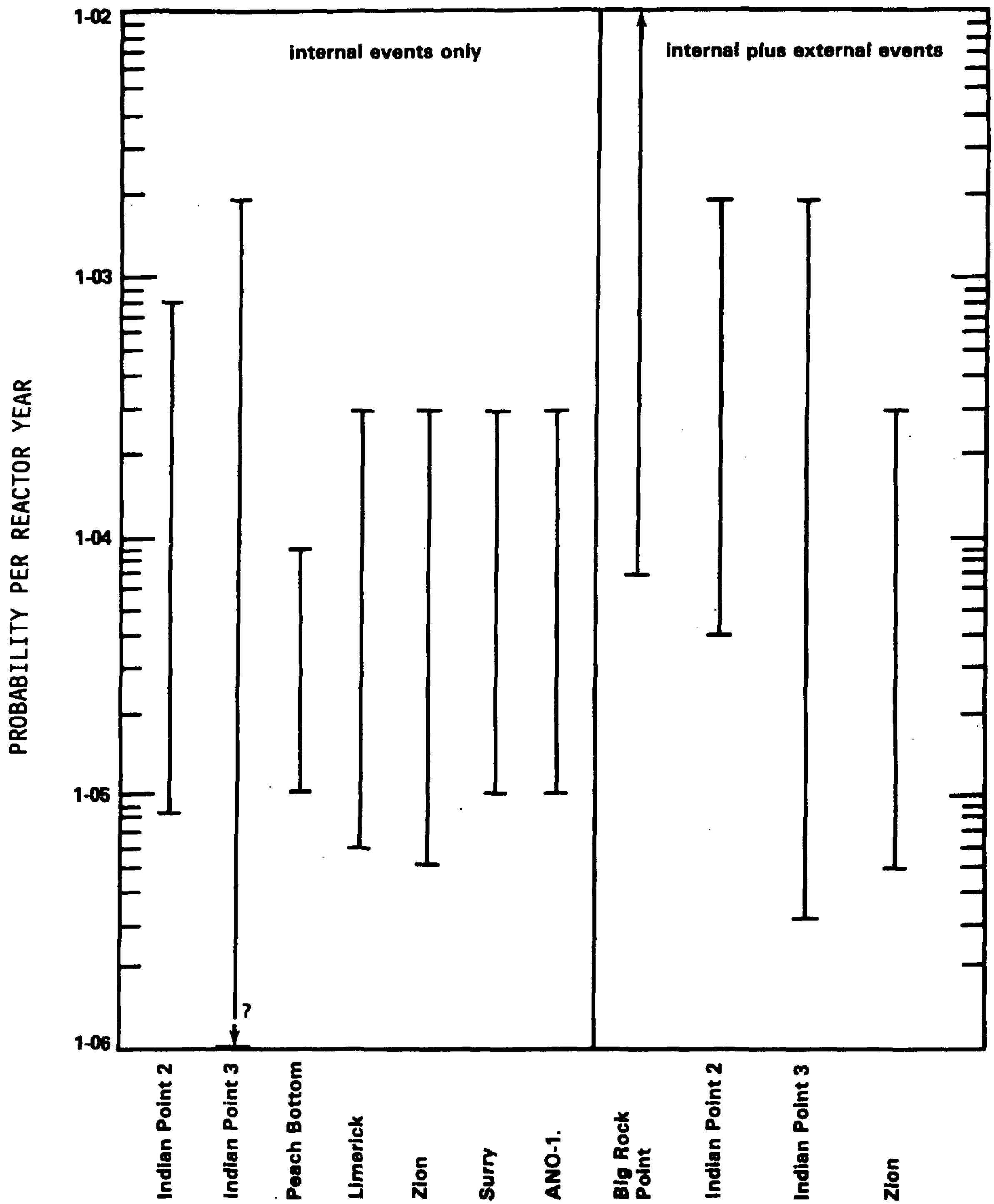

Figure 5.4m Core melt probability uncertainty bounds for internal events and internal plus external events

Atmospheric Dispersion Modeling for the Radioactive Plume Transport, Including the Physical and Chemical Behavior of Radionuclides in Particulate Form in the Atmosphere

This uncertainty is due to differences between the modeling of the atmospheric transport of radioactivity in gaseous and particulate states in the CRAC code and the actual transport, diffusion and deposition or fallout that would occur during an accident (including the effects of precipitation). The phenomenon of plume rise because of heat that is associated with the atmospheric release, effects of precipitation on the plume, and fallout of particulate matter from the plume all have considerable impact on both the magnitude of early health consequences and the distance from the reactor to which these consequences would occur. The staff judgment is that these factors can result in substantial overestimates or underestimates of both early and later effects (health and economic).

Errors of Completeness, Modeling, Arithmetic, and Omission

This area of lumped uncertainty includes such topics as the omission of a model of sabotage, modeling errors in event trees, common cause failures other than those originating in external events or fires, improvements in design or operating criteria undertaken or to be undertaken by the applicant, potential errors in the different models used to assess risks, statistical errors, and arithmetic errors. The impact on risk estimates of this class of uncertainty could be large, but is unknown and virtually impossible to quantify accurately (Rowsome, 1982). Because of the depth to which the applicant and the staff have considered risks for Limerick, however, uncertainties of this type are not expected to be as large as for other reactors for which less comprehensive probabilistic risk assessments have been performed.

Other areas that have substantial but relatively less effect on uncertainty than the preceeding items are

Duration and Energy of Release, Warning Time, and Inplant Radionuclide Decay Time

The assumed release duration, energy of release, and the warning and the inplant radioactivity decay times may differ from those that would actually occur during a real accident.

For a relatively long duration (greater than a half-hour) of an atmospheric release, the actual cross-wind spread (the width) of the radioactive plume that would develop would likely be larger than the width calculated by the dispersion model in CRAC. However, the effective width of the plume is calculated in the code using a plume expansion factor that is determined by the release duration. For a given quantity of radionuclides in a release, the plume and, therefore, the area that would come under its cover would become wider if the release duration were made longer. In effect, this would result in lower air and ground concentrations of radioactivity but a greater area of contamination.

The thermal energy associated with the release affects the plume rise phenomenon, which results in relatively lower air and ground concentrations in the closer-in regions and relatively higher concentrations as a result of fallout in the more distant regions. Therefore, if a large amount of thermal energy were associated with a release containing large fractions of core inventory of radionuclides, the distance from the reactor over which early health effects may occur is likely to be increased.

Warning time before evacuation has considerable impact on the effectiveness of offsite emergency response. Longer warning times would improve the effectiveness of the response.

The time from reactor shutdown until the beginning of the release to the environment (atmosphere), known as the time of release, is used to calculate the depletion of radionuclides by radioactive decay within the plant before release. The depletion factor for each radionuclide (determined by the radioactive decay constant and the time of release) multiplied by the release fraction of the radionuclide and its core inventory determines the actual quantity of the radionuclide released to the environment. Longer release times would result in release of fewer curies to the environment for given values of release fractions.

The first three of the parameters discussed above can have significant impacts on accident consequences, particularly early consequences. The staff judgment is that the estimates of early consequences and risks could be substantially exceeded, or could be substantial overestimates, because of uncertainties in the first three parameters.

Meteorological Sampling Scheme Used

The meteorological sequences used with the selected 91 start times (sampling) in the CRAC code may not adequately represent all meteorological variations that may occur over the life of the plant. This factor is judged to produce greater uncertainties for early effects and less for latent effects.

Emergency Response Effectiveness

The modeling assumptions of the emergency response of the people residing around the Limerick site may not correspond to what would happen during an actual severe reactor accident. Included in these considerations are such subjects as evacuation effectiveness under different circumstances, possible sheltering and its effectiveness, and the effectiveness of population relocation. The staff judgment is that the uncertainties associated with emergency response effectiveness could cause large uncertainties in estimates of early health consequences. The uncertainties in estimates of latent health consequences and costs are considered smaller than those of early health consequences. A limited sensitivity analysis in this area is presented in Appendix M. It indicates that for release categories initiated by causes other than severe earthquakes, the risk of early fatality with supportive or minimal medical treatment would be increased by factors of less than 5, if people from within the plume exposure pathway EPZ would not evacuate to evade the plume but would wait for the plume to leave the area and then relocate from the contaminated ground after a time interval equal to the evacuation time assumed for the Limerick site. Under the same assumptions, increases in risks of other health effects would be less. However, the increase in risks of all health effects from release categories initiated by all causes (severe earthquakes and other causes) taken together would be within about 20%.

- Dose Conversion Factors and Dose Response Relationships for Early Health Consequences, Including Benefits of Medical Treatment

  There are many uncertainties associated with estimates of dose and early health effects on individuals exposed to high levels of radiation. Included are the uncertainties associated with the conversion of contamination levels to doses, relationships of doses to health effects, and considerations of the availability of what was described in the RSS as supportive medical treatment (a specialized medical treatment program of limited resources that would minimize the early health effect consequences of high levels of radiation exposure following a severe reactor accident). The staff analysis shows that the variation in estimates of early fatality risks stemming from considerations of supportive medical treatment alone is less than a factor of 3 for the Limerick site.

- Dose Conversion Factors and Dose Response Relationships for Latent Health Consequences

  In comparison to early health effects, there are even larger uncertainties associated with dose estimates and latent (delayed and long-term) health effects on individuals exposed to lower levels of radiation and on their succeeding generations. Included are the uncertainties associated with conversion of contamination levels to doses and doses to health effects. The staff judgment is that this category has a large uncertainty. The uncertainty could result in relatively small underestimates of consequences, but it also could result in substantial overestimates of consequences. (Note: radiobiological evidence on this subject does not rule out the possibility that low level radiation could produce zero consequences.)

- Chronic Exposure Pathways, Including Environmental Decontamination and the Fate of Deposited Radionuclides

  Uncertainties are associated with chronic exposure pathways to people from long-term use of the contaminated environment. Uncertainty also arises from the possibility that the protective action guide levels that may actually be used for interdiction or decontamination of the exposure pathways may differ from those assumed in the staff analysis. Further, uncertainty arises as a result of the lack of precise knowledge about the fate of the radionuclides in the environment as influenced by such natural processes as runoff, weathering, etc. The staff's qualitative judgment is that the uncertainty from these considerations is substantial.

- Economic Data and Modeling

  There are uncertainties in the economic parameters and economic modeling, such as costs of evacuation, relocation, medical treatment, cost of decontamination of properties, and other costs of property damage. Uncertainty in this area could be substantial.

- Fission Product Inventory

  The fission product inventory presented in Table 5.11a is an approximation of that which would be present after extended operation at maximum power. The amount of each isotope listed will, in fact, vary with time in a manner dependent upon the fuel management scheme and the power history of the core. The actual inventory at the time of an accident could not be much larger for any isotope than the amount in Table 5.11a, but, especially for long-lived fission products, could be substantially smaller.

The means for quantitative evaluation of the uncertainties in a probabilistic risk analysis such as the type presented here are not well developed. The staff, however, has attempted to identify all sources of uncertainty, and to assess the net effect upon the uncertainty of the risk estimates. Based upon the insight gained from the review of similar PRAs for Indian Point and Zion, it is the judgment of the staff that the risk estimates for Limerick could be too low by a factor of about 40 or too high by a factor of about 400. The risk estimates are equal to the integrals of the corresponding probability distributions of the consequences (CCDFs). As a result, errors in probabilities and consequences are partially offset. Because of the magnitude of uncertainties, the staff has concluded that estimates of the absolute magnitudes of probabilities, consequences, and risks do not provide an accident perspective unless the uncertainties are also considered.

When the accident at Three Mile Island occurred in March 1979, the accumulated experience record was about 400 reactor-years. It is of interest to note that this was within the range of frequencies estimated by the RSS for an accident of this severity (National Research Council, 1979, p. 553). It should also be noted that the Three Mile Island accident has resulted in a very comprehensive evaluation of similar reactor accidents by a number of investigative groups both within and outside of the NRC. Actions to improve the safety of nuclear power plants have resulted from these investigations, including those from the President's Commission on the Accident at Three Mile Island and from NRC staff investigations and task forces. A comprehensive "NRC Action Plan Developed as a Result of the TMI-2 Accident" (NUREG-0660, Vol I) collects the various recommendations of these groups and describes them under the subject areas of: Operational Safety; Siting and Design; Emergency Preparedness and Radiation Effects; Practices and Procedures; and NRC Policy, Organization, and Management. NUREG-0737, "Clarification of TMI Action Plan Requirements," and Supplement 1 to NUREG-0737 identified those requirements that were approved for implementation. The action plan presents a sequence of actions, some already taken, that results in a gradually increasing improvement in safety as individual actions are completed. The Limerick units are receiving and will receive the benefit of these actions on the schedule discussed in the SER. The improvement in safety from these actions has not been quantified, however.

(8) Comparison of Limerick Risks with Other Plants

To provide a perspective as to how the Limerick reactors compare in terms of risks from severe accidents with some of the other nuclear power plants that are either operating or that are being reviewed by the staff for possible issuance of a license to operate, the estimated risks from severe accidents for several nuclear power plants (including those for Limerick) are shown in Figures 5.4n through 5.4v for three important categories of risk. The values for individual

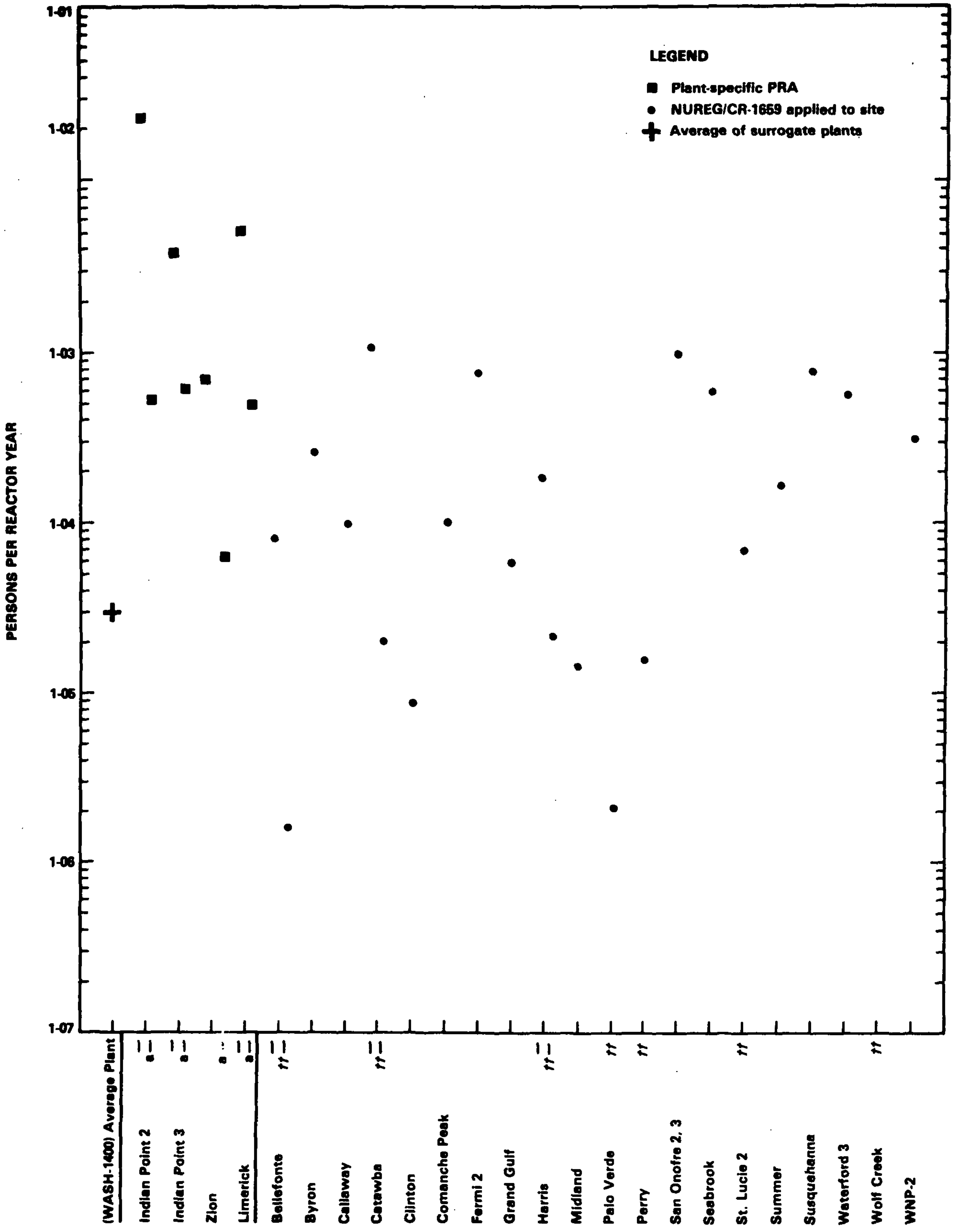

Figure 5.4n Estimated early fatality risk with supportive medical treatment (persons) from severe reactor accidents for several nuclear power plants either operating or receiving consideration for issuance of license to operate. See footnotes following Figure 5.4v.

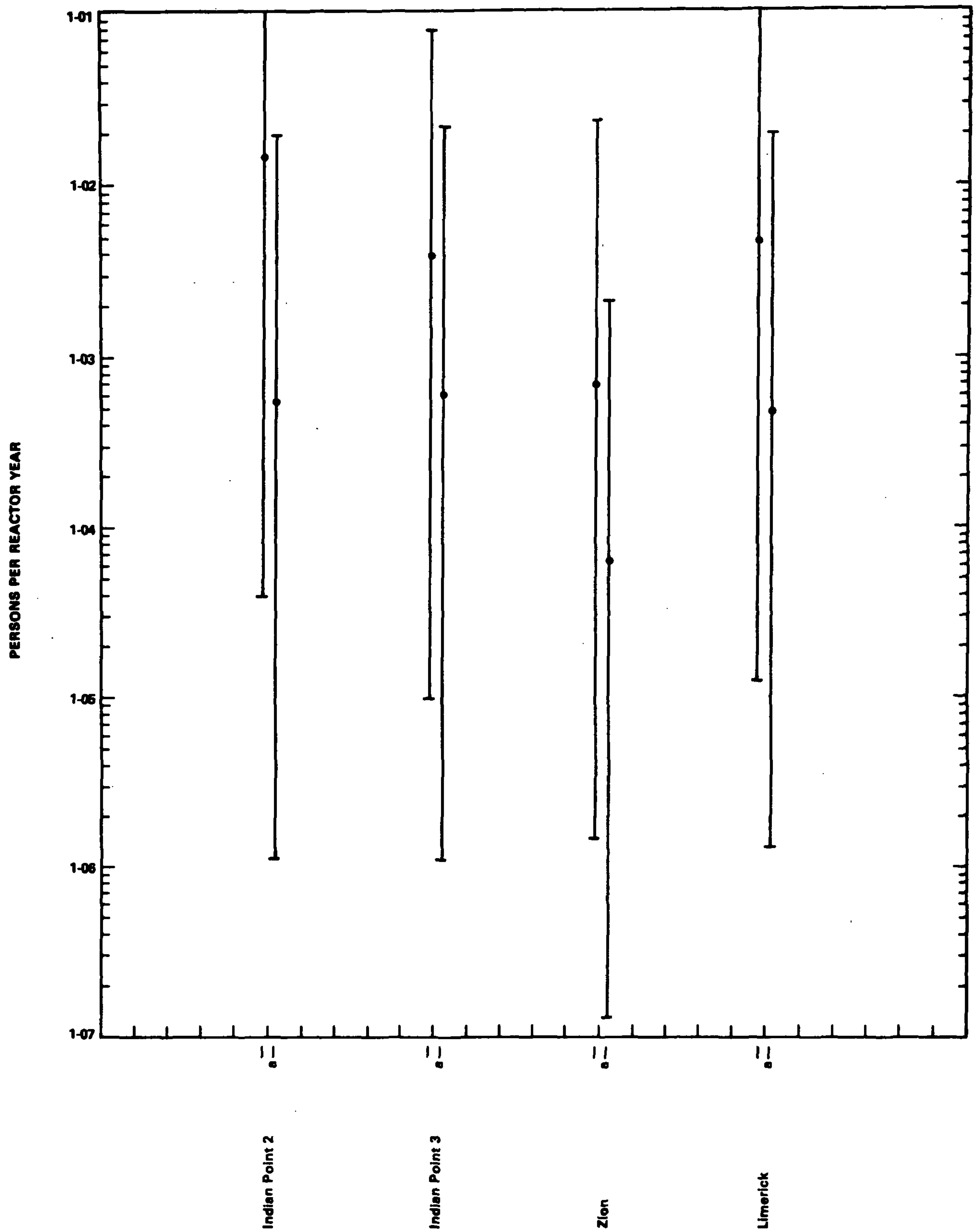

Figure 5.4o Estimated early fatality risk with supportive medical treatment (persons) from severe reactor accidents for nuclear power plants having plant-specific PRAs, showing estimated range of uncertainties. See footnotes following Figure 5.4v.

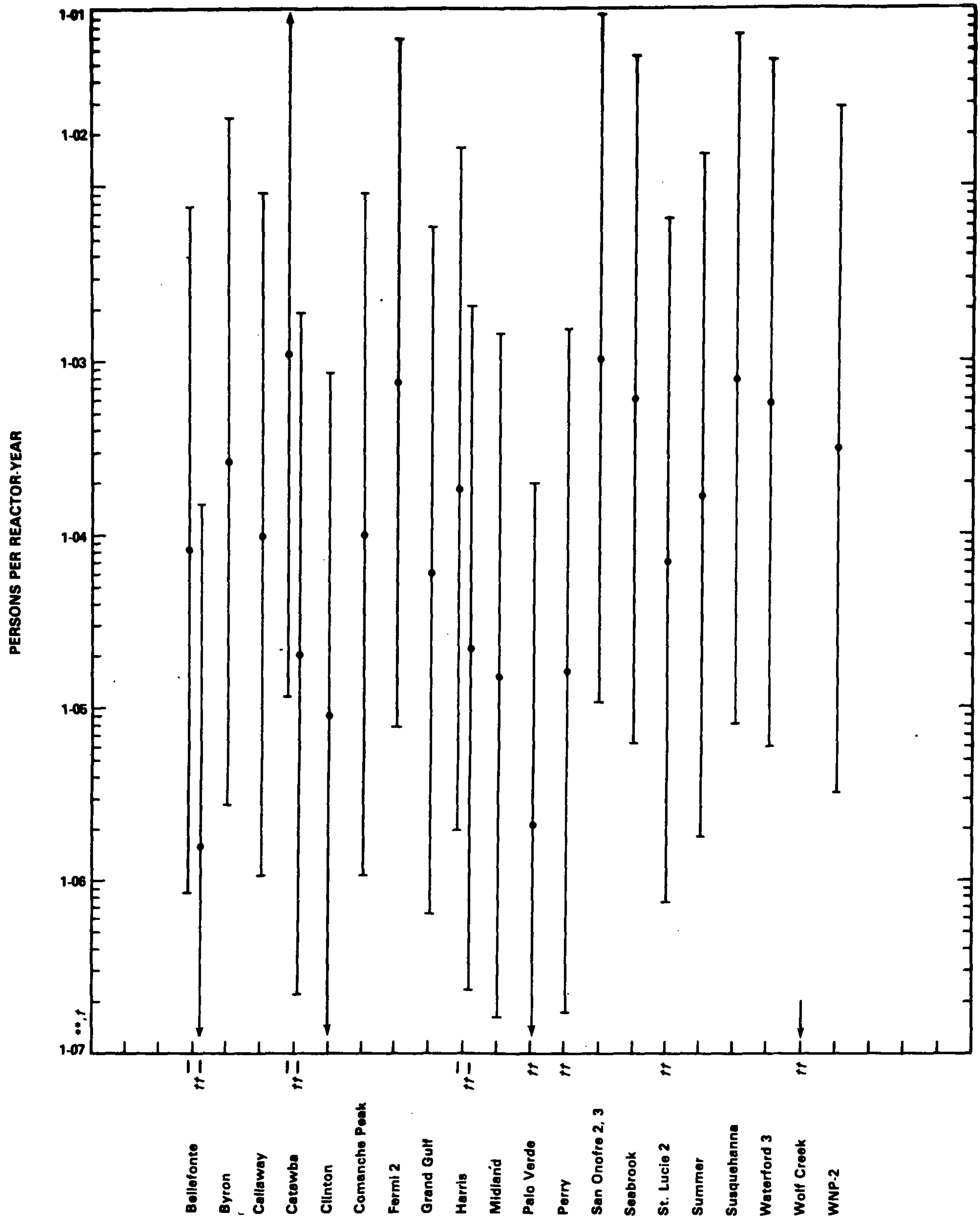

Figure 5.p Estimated early fatality risk with supportive medical treatment (persons) from severe reactor accidents for several nuclear power plants either operating or receiving consideration for issuance of license to operate for which site-specific applications of NUREG/CR-1695 accident releases have been used to calculate off-site consequences. Bars are drawn to illustrate effect of uncertainty range discussed in text. See footnotes following Figure 5.4v.

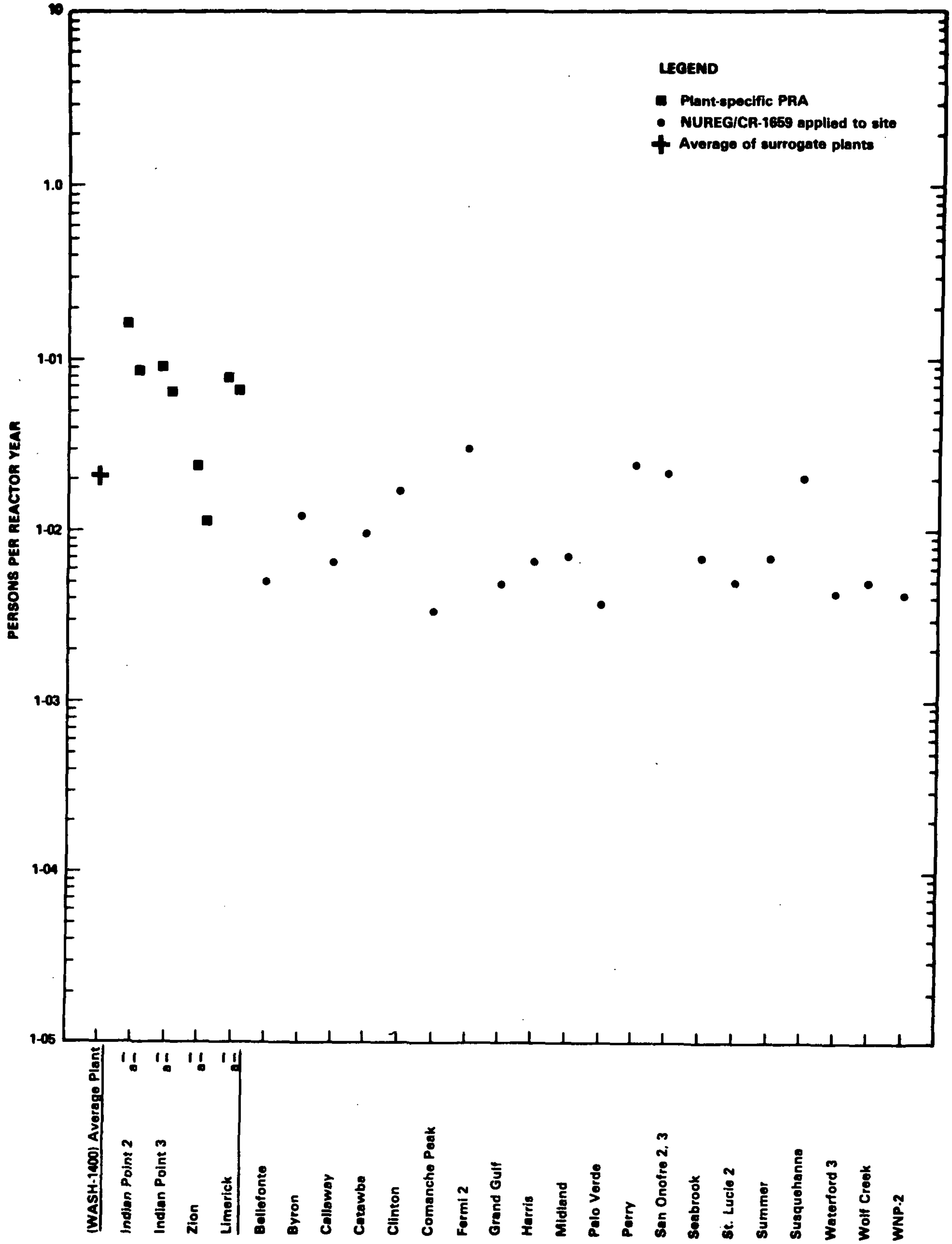

Figure 5.4q Estimated latent cancer fatality risk, excluding thyroid (persons) from severe reactor accidents for several nuclear power plants either operating or receiving consideration for issuance of license to operate. See footnotes at the end of Figure 5.4v.

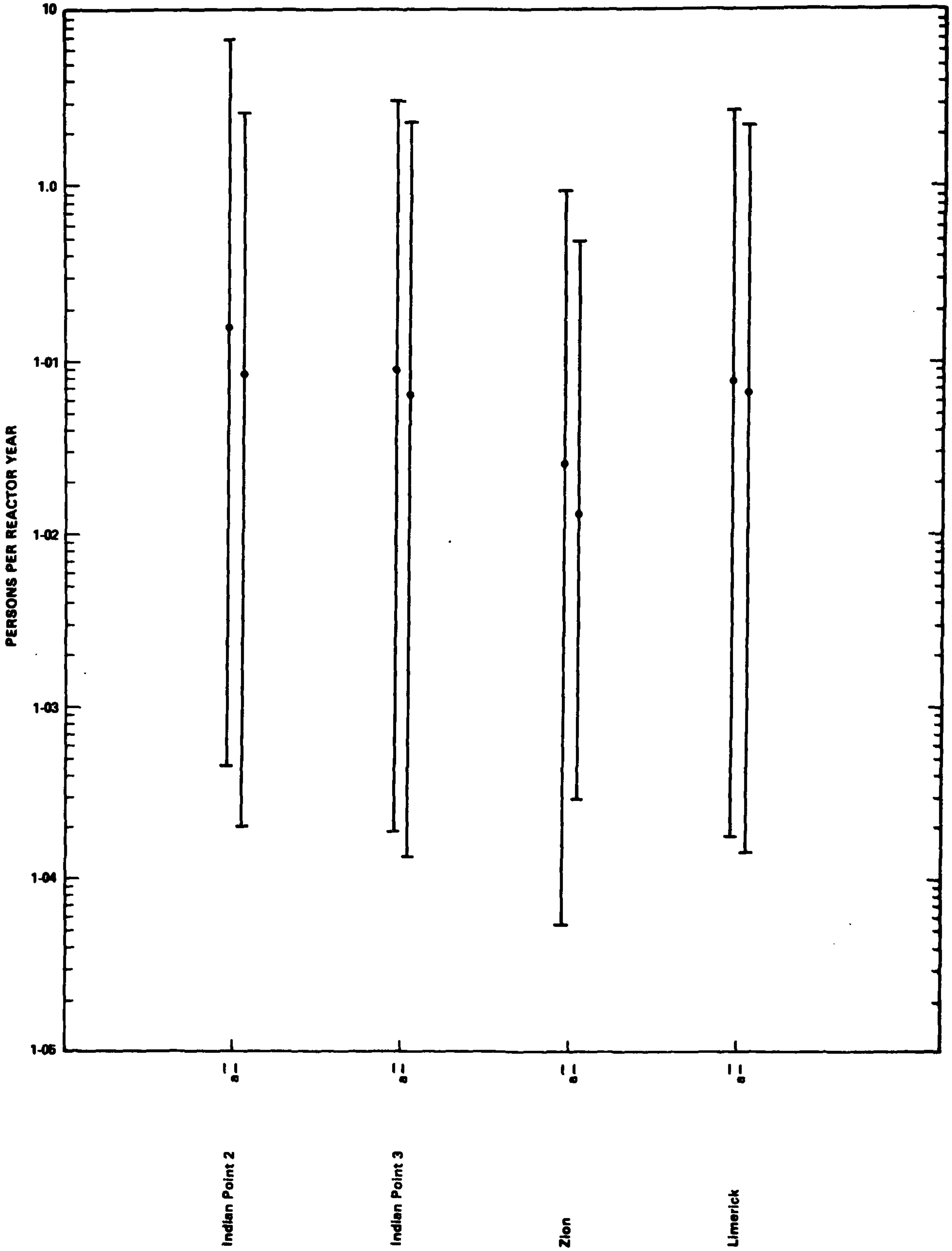

Figure 5.4r Estimated latent cancer fatality risk, excluding thyroid (persons) from severe reactor accidents for nuclear power plants having plant-specific PRAs, showing estimated range of uncertainties. See footnotes at the end of Figure 5.4v.

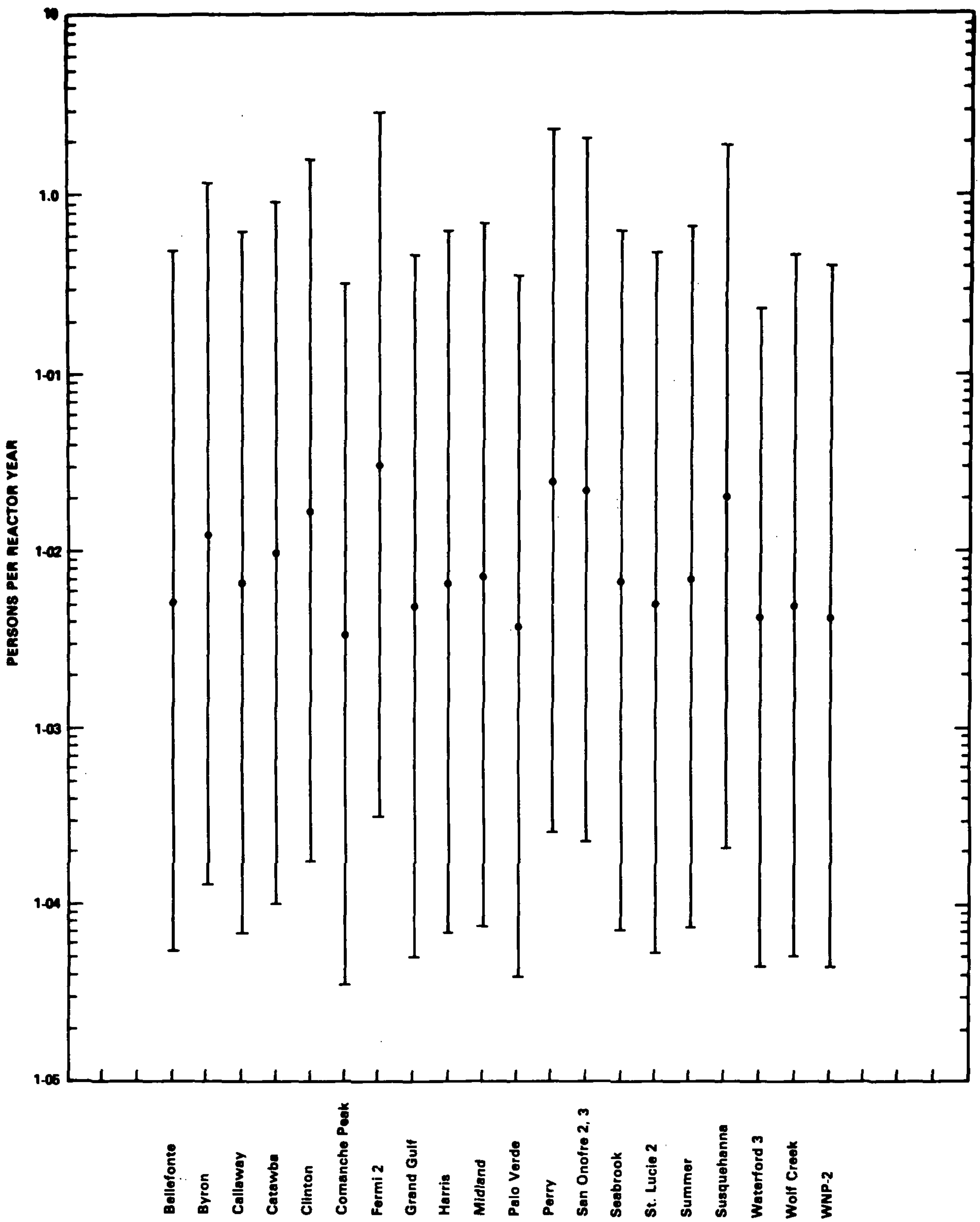

Figure 5.4s Estimated latent cancer fatality risk, excluding thyriod (persons) from severe reactor accidents for several nuclear power plants either operating or receiving consideration for issuance of license to operate for which site-specific applications of NUREG/CR-1695 accident releases have been used to calculate off-site consequences. Bars are drawn to illustrate effect of uncertainty range discussed in text. See footnotes at the end of Figure 5.4v.

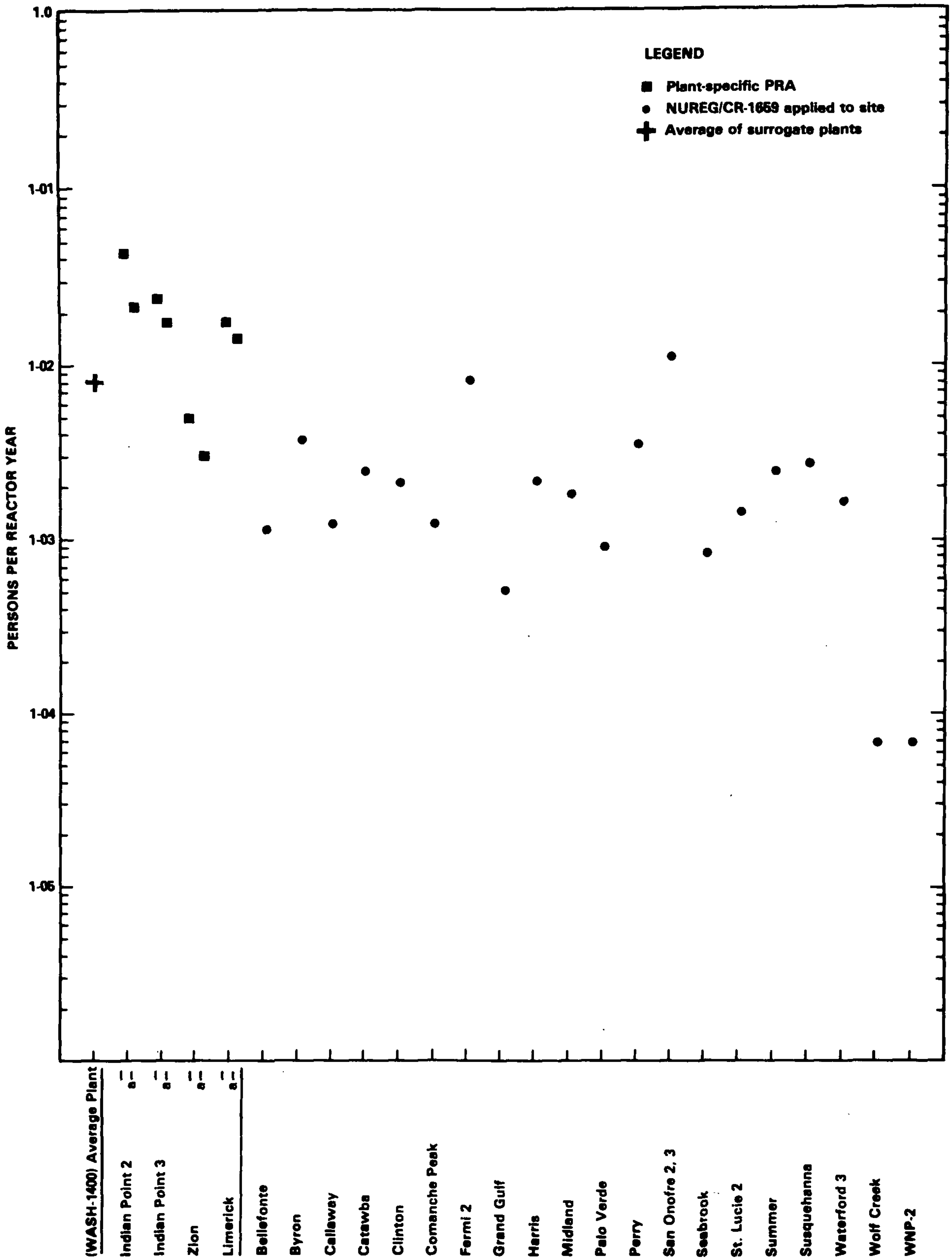

Figure 5.4t Estimated latent thyroid cancer fatality risk (persons) from severe reactor accidents for several nuclear power plants either operating or receiving consideration for issuance of license to operate. See footnotes at the end of Figure 5.4v.

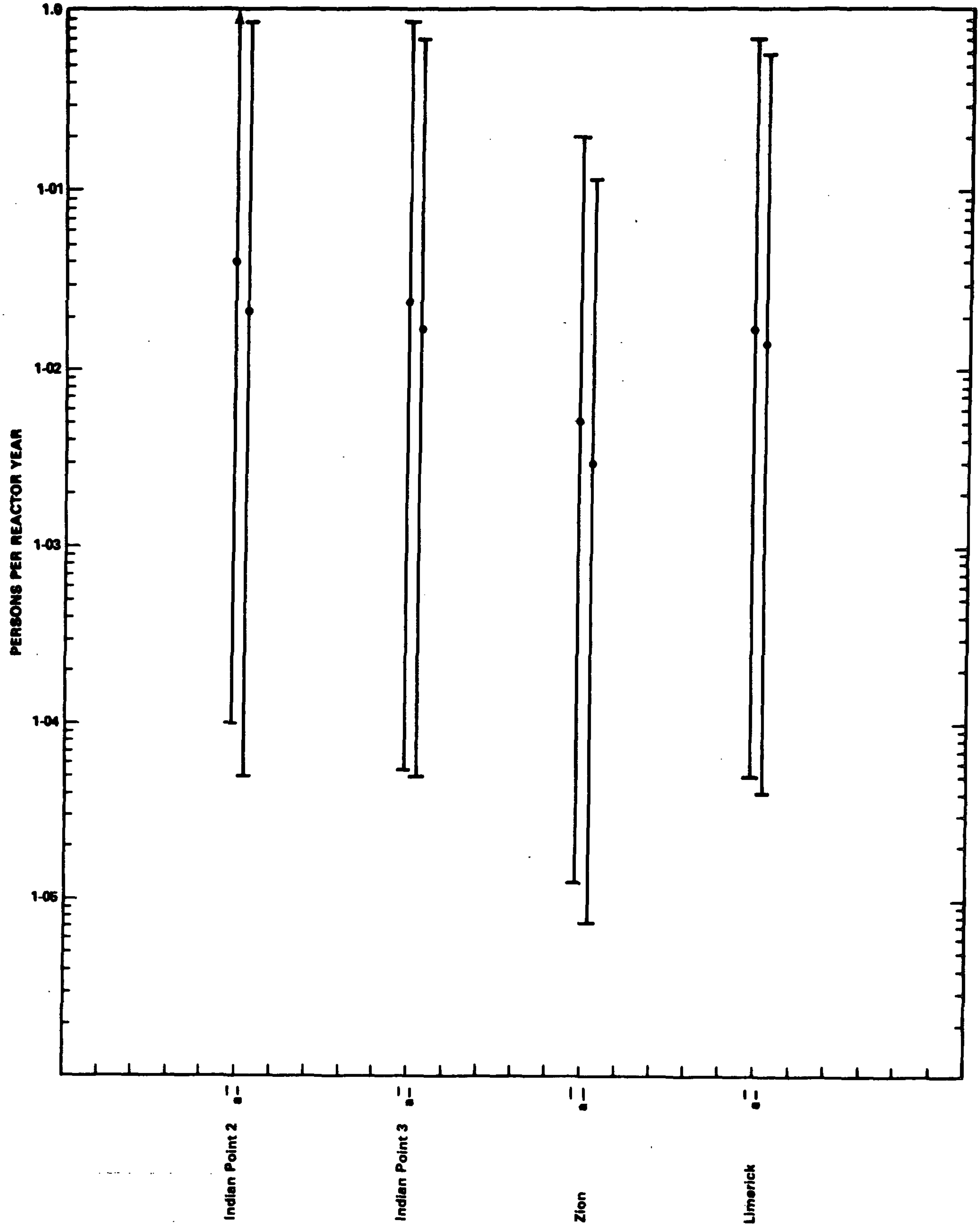

Figure 5.4u Estimated latent thyroid cancer fatality risk (persons) from severe reactor accidents for nuclear power plants having plant-specific PRAs, showing estimated range of uncertainties. See footnotes at the end of Figure 5.4v.

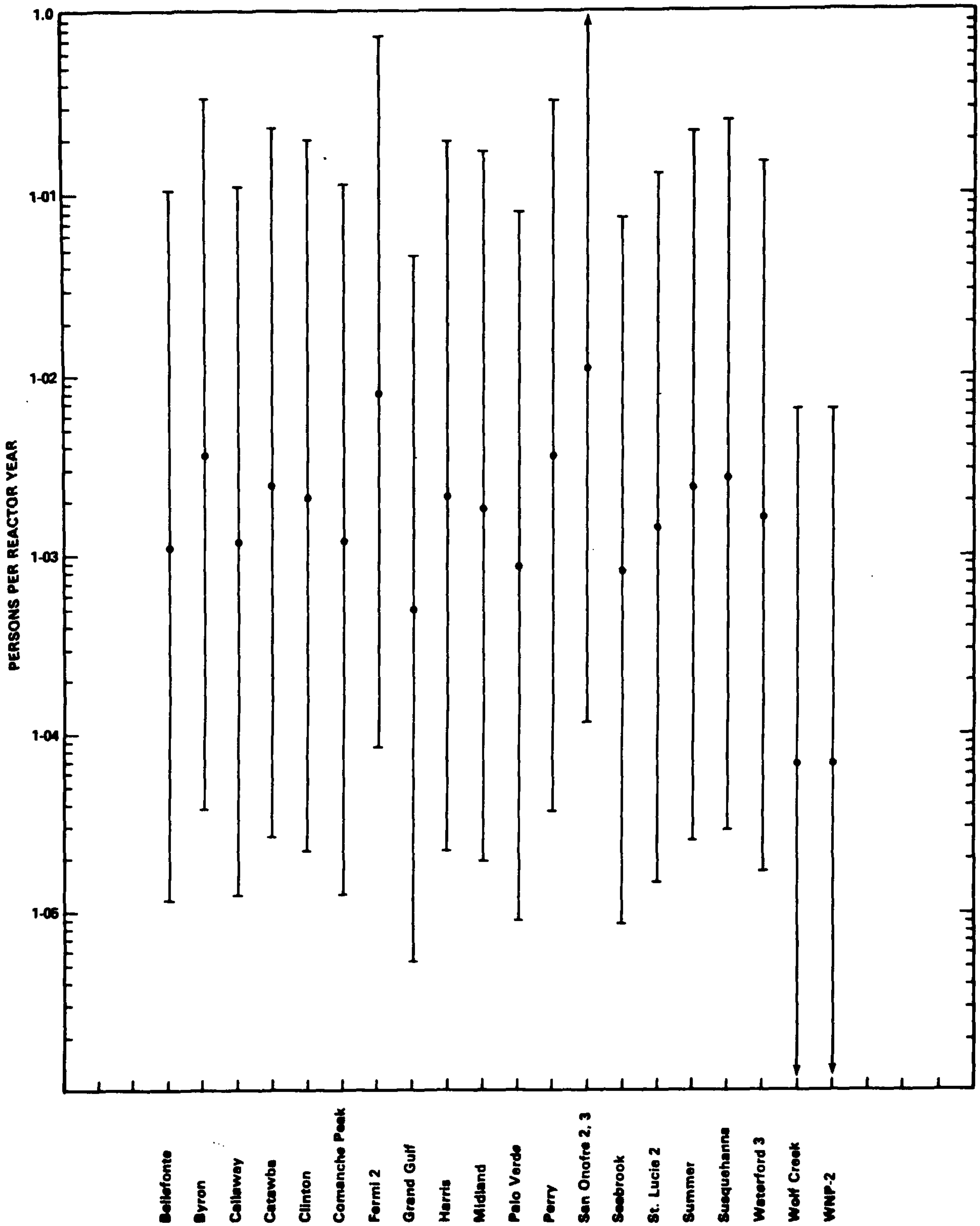

Figure 5.4v Estimated latent thyroid cancer fatality risk (persons) from severe reactor accidents from several nuclear power plants either operating or receiving consideration for issuance of license to operate for which site-specific applications of NUREG-1695 accident releases have been used to calculate off-site consequences. Bars are drawn to illustrate effect of uncertainty range discussed in text. See footnotes on following page.

Notes for Figures 5.4n through 5.4v

• Except for Indian Point, Zion, and Limerick, risk analyses for other plants in these figures are based on WASH-1400 generic source terms and probabilities for severe accidents and do not include external event analyses. Any or all of the values could be under or over-estimates of the true risks.

• 1-01 = 1×10^{-1}

†Assumes evacuation to 25 miles.

††With evacuation within 10 miles and relocation from 10-25 miles.

[a]Excluding severe earthquakes and hurricanes.

NOTE: Please see Section 5.9.4.5(7) for discussion of uncertainties.

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plants are based upon three types of estimates: from the RSS (labeled WASH-1400 Average Plant), from independent staff reviews of contemporary probabilistic risk assessments (Indian Point 2 and 3, Zion and Limerick), and from generic applications of RSSMAP accident sequences to reactor sites for environmental statements by the staff (for 21 nuclear power plants). The RSS risk estimates were intended to illustrate the general level of risk from a variety of plant designs at a variety of sites, and these estimates appear in Figures 5.4n, q and t as point estimates along with the corresponding point estimates obtained by the other types of analysis. Figures 5.4o, r and u show the range of uncertainty that is estimated for those four plants for which a plant-specific probabilistic risk assessment has been performed. Figures 5.4p, s and v are included to illustrate the effect uncertainties of a factor of 100 would have upon comparison amongst risk estimates using a fixed set of accident sequences, but site-specific meteorology and population. The display of risk in three sets of figures is intended to allow comparison of risks similarly evaluated, and to allow an overall comparison of risks to be made among all types of risk evaluations available. Figures 5.4n through 5.4v indicate that the estimated Limerick risks may be higher than those for some plants, and lower than those for several other plants but, except for early fatalities at the Wolf Creek site, not by a margin that would exceed the uncertainties in the estimates themselves. Similarly, Figure 5.4m, which compares core melt probabilities for Limerick with several other reactors, indicates that the estimated likelihood of a core melt accident at Limerick is roughly the same as for several operating reactors. Furthermore, any or all of the estimates of risk could be under or overestimates.

5.9.4.6 Conclusions

The foregoing sections consider the potential environmental impacts from accidents at Limerick station. These have covered a broad spectrum of possible accidental releases of radioactive materials into the environment by atmospheric and liquid pathways. Included in the considerations are postulated design-basis accidents and more severe accident sequences that lead to a severely damaged reactor core or core melt. The applicant also considered similar accidents in the ER-OL. The staff has considered the technical merits of the applicant's assessment and the uncertainties involved, and agrees in several areas and disagrees in several other areas (see Appendix N). Noteable disagreements are in the area of source terms and offsite emergency response modeling. For several sequences the staff's source terms are considerably higher; the offsite emergency response modeling is site specific and more pessimistic for severe earthquake conditions in the site region than that modeled by the applicant. As a result, the applicant's risk estimates are substantially lower than the staff estimates. In both the applicant's and the staff's analyses of accident risk, however, there are very large uncertainties.

This section documents the staff's use of PRA in its inquiry into the environmental impacts of reactor accidents. The staff's inquiry into the implications of the risk assessments for reactor design and operation; to wit, questions of compliance with the reactor safety regulations and the questions of whether plant-specific vulnerabilities to severe accidents warrant requirements more stringent than the norm, will be documented elsewhere.

The environmental impacts that have been considered include potential radiation exposures to individuals and to the population as a whole, the estimated likelihood of core melt accidents, the risk of near- and long-term adverse health effects that such exposures could entail, and the potential economic and societal consequences of accidental contamination of the environment. These impacts could be severe, but the likelihood of their occurrence is judged to be small and comparable to that of other reactors. This conclusion is based on (1) the fact that considerable experience has been gained with the operation of similar facilities without significant degradation of the environment, (2) the fact that, to obtain a license to operate, the Limerick station must comply with the applicable Commission regulations and requirements, (3) a comparison with the estimated core melt probabilities of other reactors, and (4) a probabilistic assessment of the risk based upon the methodology developed in the RSS, improvements on the RSS methodology including external event analysis, and a sensitivity analysis of offsite emergency response modeling. The overall assessment of environmental risk of accidents, assuming protective actions, shows that the risks of population exposure and latent cancer fatality are within a factor of 30 of those from normal operation. Accidents have a potential for early fatalities and economic costs that cannot arise from normal operations; however, the risks of early fatality from potential accidents at the site are small in comparison with risks of early fatality from other human activities in a comparably sized population, and the accident risk will not add significantly to population exposure and cancer risks. Accident risks from Limerick are expected to be a small fraction of the risks the general public incurs from other sources. Further, the best estimate calculations show that the risks of potential reactor accidents at Limerick are within the range of such risks from other nuclear power plants.

Based on the foregoing considerations of environmental impacts of accidents, which have not been found to be significant, the staff has concluded that there are no special or unique circumstances about the Limerick site and environs that would warrant consideration of alternatives for Limerick Units 1 and 2.

5.10 Impacts from the Uranium Fuel Cycle

The Uranium Fuel Cycle rule, 10 CFR 51.20 (44 FR 45362), reflects the latest information relative to the reprocessing of spent fuel and to radioactive waste management as discussed in NUREG-0116, "Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle" (1976), and NUREG-0216 (1977), which presents staff responses to comments on NUREG-0116. The rule also considers other environmental factors of the uranium fuel cycle, including aspects of mining and milling, isotopic enrichment, fuel fabrication, and management of low- and high-level wastes. These are described in the AEC report WASH-1248, "Environmental Survey of the Uranium Fuel Cycle" (1974). In 1974, the Commission directed the NRC staff to develop an explanatory narrative that would convey in understandable terms the significance of releases in the table. The narrative was also to address such important fuel cycle impacts as environmental dose commitments and health effects, socioeconomic impacts, and cumulative impacts, where these are appropriate for generic treatment. This explanatory narrative was published in the Federal Register on March 4, 1981 (46 FR 15154-15175). Appendix C to this report contains a number of sections that address those impacts of the LWR-supporting fuel cycle that reasonably appear to have significance for individual reactor licensing sufficient to warrant attention for NEPA purposes.

Table S-3 of the final rule is reproduced in its entirety as Table 5.12 herein. Specific categories of natural resource use included in the table relate to land use, water consumption and thermal effluents, radioactive releases, burial of transuranic and high- and low-level wastes, and radiation doses from transportation and occupational exposures. The contributions in the table for reprocessing, waste management, and transportation of wastes are maximized for either of the two fuel cycles (uranium only and no recycle); the cycle that results in the greater impact is used.

On April 27, 1982, the U.S. Court of Appeals for the District of Columbia Circuit issued a decision that found the S-3 rule invalid "due to their failure to allow for proper consideration of the uncertainties that underlie the assumption that solidified high-level and transuranic wastes will not affect the environment once they are sealed in a permanent repository" (Natural Resources Defense Council vs. NRC, No. 74-1586, D.C. Circuit). By its order of September 1, 1982, the D.C. Circuit delayed implementation of its earlier decision pending the filing of application for review of the decision by the U.S. Supreme Court. On November 1, 1982, the Commission issued a Statement of Policy concerning this decision (see 47 FR 50591, November 8, 1982). The Commission, in the Statement of Policy, directed its Licensing and Appeal Boards to proceed in continued reliance on the S-3 rule until further order from the Commission, "provided that any license authorizations or other decisions issued in reliance on the rule are conditioned on the final outcome of the judicial proceedings."

Subsequently, on June 6, 1983, the Supreme Court, in Baltimore Gas and Electric Co. vs. Natural Resources Defense Council, overturned the Court of Appeals decision and held that the Commission's adoption of a generic rule to evaluate the environmental effects of a nuclear plant's fuel cycle was not arbitrary and capricious within the meaning of Paragraph 10(a) of the Administrative Procedure Act. The zero-release assumption was found to be within the bounds of reasoned decisionmaking and, under the circumstances surrounding its use, in compliance with NEPA requirements concerning consideration and disclosure of the environmental impacts of licensing decisions. As a result of the decision in Baltimore Gas and Electric Co., NRC license authorization and other decisions may rely unconditionally on the numerical values in Table S-3 (Table 5.12 in this report).

Table 5.12 (Summary Table S-3) Uranium fuel cycle environmental data[1]

[Normalized to model LWR annual fuel requirement [WASH-1248] or reference reactor year [NUREG-0116]]

Environmental considerations	Total	Maximum effect per annual fuel requirement or reference reactor year of model 1,000 MWe LWR
NATURAL RESOURCES USE		
Land (acres):		
Temporarily committed[2]	100	
Undisturbed area	79	
Disturbed area	22	Equivalent to a 110 MWe coal-fired power plant.
Permanently committed	13	
Overburden moved (millions of MT)	2.8	Equivalent to 95 MWe coal-fired power plant.
Water (millions of gallons):		
Discharged to air	160	=2 percent of model 1,000 MWe LWR with cooling tower.
Discharged to water bodies	11,090	
Discharged to ground	127	
Total	11,377	<4 percent of model 1,000 MWe LWR with once-through cooling.
Fossil fuel:		
Electrical energy (thousands of MW-hour)	323	<5 percent of model 1,000 MWe LWR output.
Equivalent coal (thousands of MT)	118	Equivalent to the consumption of a 45 MWe coal-fired power plant.
Natural gas (millions of scf)	135	<0.4 percent of model 1,000 MWe energy output.
EFFLUENTS—CHEMICAL (MT)		
Gases (including entrainment):[3]		
SO_x	4,400	
NO_x[4]	1,190	Equivalent to emissions from 45 MWe coal-fired plant for a year.
Hydrocarbons	14	
CO	29.6	
Particulates	1,154	
Other gases:		
F	.67	Principally from UF_6 production, enrichment, and reprocessing. Concentration within range of state standards—below level that has effects on human health.
HCl	.014	
Liquids:		
SO_4^-	9.9	From enrichment, fuel fabrication, and reprocessing steps. Components that constitute a potential for adverse environmental effect are present in dilute concentrations and receive additional dilution by receiving bodies of water to levels below permissible standards. The constituents that require dilution and the flow of dilution water are: NH_3—600 cfs. NO_3—20 cfs. Fluoride—70 cfs.
NO_3^-	25.8	
Fluoride	12.9	
Ca^{++}	5.4	
Cl^-	8.5	
Na^+	12.1	
NH_3	10.0	
Fe	.4	
Tailings solutions (thousands of MT)	240	From mills only—no significant effluents to environment.
Solids	91,000	Principally from mills—no significant effluents to environment.

Table 5.12 (Continued)

[Normalized to model LWR annual fuel requirement [WASH-1248] or reference reactor year [NUREG-0116]]

Environmental considerations	Total	Maximum effect per annual fuel requirement or reference reactor year of model 1,000 MWe LWR
EFFLUENTS—RADIOLOGICAL (CURIES)		
Gases (including entrainment):		
Rn-222		Presently under reconsideration by the Commission.
Ra-226	.02	
Th-230	.02	
Uranium	.034	
Tritium (thousands)	18.1	
C-14	24	
Kr-85 (thousands)	400	
Ru-106	.14	Principally from fuel reprocessing plants.
I-129	1.3	
I-131	.83	
Tc-99		Presently under consideration by the Commission.
Fission products and transuranics	.203	
Liquids:		
Uranium and daughters	2.1	Principally from milling—included tailings liquor and returned to ground—no effluents; therefore, no effect on environment.
Ra-226	.0034	From UF_6 production.
Th-230	.0015	
Th-234	.01	From fuel fabrication plants—concentration 10 percent of 10 CFR 20 for total processing 26 annual fuel requirements for model LWR
Fission and activation products	5.9×10^{-6}	
Solids (buried on site):		
Other than high level (shallow)	11,300	9,100 Ci comes from low level reactor wastes and 1,500 Ci comes from reactor decontamination and decommissioning—buried at land burial facilities. 600 Ci comes from mills—included in tailings returned to ground. Approximately 60 Ci comes from conversion and spent fuel storage. No significant effluent to the environment.
TRU and HLW (deep)	1.1×10^{7}	Buried at Federal Repository.
Effluents—thermal (billions of British thermal units)	4,063	<5 percent of model 1,000 MWe LWR.
Transportation (person-rem):		
Exposure of workers and general public	2.5	
Occupational exposure (person-rem)	22.6	From reprocessing and waste management

[1] In some cases where no entry appears it is clear from the background documents that the matter was addressed and that, in effect, the Table should be read as if a specific zero entry had been made. However, there are other areas that are not addressed at all in the Table. Table S-3 does not include health effects from the effluents described in the Table, or estimates of releases of Radon-222 from the uranium fuel cycle or estimates of Technetium-99 released from waste management or reprocessing activities. These issues may be the subject of litigation in the individual licensing proceedings.

Data supporting this table are given in the "Environmental Survey of the Uranium Fuel Cycle," WASH-1248, April 1974; the "Environmental Survey of the Reprocessing and Waste Management Portion of the LWR Fuel Cycle," NUREG-0116 (Supp. 1 to WASH-1248), the "Public Comments and Task Force Responses Regarding the Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle," NUREG-0216 (Supp. 2 to WASH-1248), and in the record of the final rulemaking pertaining to Uranium Fuel Cycle Impacts from Spent Fuel Reprocessing and Radioactive Waste Management, Docket RM-50-3. The contributions from reprocessing, waste management and transportation of wastes are maximized for either of the two fuel cycles (uranium only and no recycle). The contribution from transportation excludes transportation of cold fuel to a reactor and of irradiated fuel and radioactive wastes from a reactor which are considered in Table S-4 of § 51.20(g). The contributions from the other steps of the fuel cycle are given in columns A-E of Table S-3A of WASH-1248.

[2] The contributions to temporarily committed land from reprocessing are not prorated over 30 years, since the complete temporary impact accrues regardless of whether the plant services one reactor for one year or 57 reactors for 30 years.

[3] Estimated effluents based upon combustion of equivalent coal for power generation.

[4] 1.2 percent from natural gas use and process.

Appendix C to this report contains a description of the environmental impact assessment of the uranium fuel cycle as related to the operation of the Limerick facility. The environmental impacts are based on the values given in Table S-3, and on an analysis of the radiological impact from radon-222 and technetium-99 releases. The NRC staff has determined that the environmental impact of this facility on the U.S. population from radioactive gaseous and liquid releases (including radon and technetium) due to the uranium fuel cycle is very small when compared with the impact of natural background radiation. In addition, the nonradiological impacts of the uranium fuel cycle have been found to be acceptable.

5.11 Decommissioning

The purposes of decommissioning are (1) to safely remove nuclear facilities from service and (2) to remove or isolate the associated radioactivity from the environment so that part of the facility site that is not permanently committed can be released for other uses. Alternative methods of accomplishing these purposes and the environmental impacts of each method are discussed in NUREG-0586.

Since 1960, 68 nuclear reactors--including 5 licensed reactors that had been used for the generation of electricity--have been or are in the process of being decommissioned. Although, to date, no large commercial reactor has undergone decommissioning, the broad base of experience gained from smaller facilities is generally relevant to the decommissioning of any type of nuclear facility.

Section 5.3 of NUREG-0586 presents estimates of radiation doses to members of the public and to plant workers for decommissioning of a reference boiling water reactor.

Radiation doses to the public as a result of end-of-life decommissioning activities should be small; they will come primarily from the transportation of waste to appropriate repositories. Radiation doses to decommissioning workers should be well within the occupational exposure limits imposed by regulatory requirements.

The NRC is currently conducting generic rulemaking that will develop a more explicit overall policy for decommissioning commercial nuclear facilities.

Specific licensing requirements are being considered that include the development of decommissioning plans and financial arrangements for decommissioning nuclear facilities.

5.12 Noise

5.12.1 Noise Impacts in the Vicinity of the Point Pleasant Pumphouse

Four sources must be considered in an evaluation of the impact of noise from the Point Pleasant pumphouse on nearby residents. These are

(1) noise transmission through the pumphouse walls

(2) noise emanating from the heating, ventilating, and air conditioning (HVAC) system

(3) noise emanating from the outside doors (leaks through the seals in the doors)

(4) noise radiated from the two transformers outside the pumphouse building

Figure 5.5 shows the location of the pumphouse, the two transformers, and the four nearest residences.

5.12.1.1 Noise Transmitted Through Pumphouse Walls

Noise sources in the Point Pleasant pumphouse are the electrical motors for each of three pumps and two compressors. The reverberant noise level inside the pumphouse resulting from operation of the three pump motors and two compressors was calculated. However, the attenuation of pump motor and compressor noise because of the 30-cm (12-in.)-thick concrete walls is approximately 60 dB, and attenuation because of the pumphouse walls and as a result of distance from the walls to the site boundary resulted in an increase in ambient noise level of less than 1 dB at the site boundary. This increase is insignificant and cannot be detected by the human ear.

Table 5.13 summarizes those calculations for noise transmitted through the pumphouse walls. Interior sound pressure levels are calculated from the sound power of the three 2250-hp 900-rpm vertical pump drive motors and the two 25-hp reciprocating air compressors. The steps in the calculation are summarized as follows:

(1) The specified pump motor noise limit of 86 dBA at 1 m (per IEEE Standard 85) and use of Bolt Beranek and Newman (1978) yields the sound power levels given in Step 1a of Table 5.13 for three pump motors. (It should be noted that the power level values in the 1-kHz octave band are predominantly tonal components that are characteristic of this type of motor.) The sound power values listed in Step 1b of Table 5.13 for the two air compressors were also calculated in accordance with Bolt Beranek and Newman. The logarithmic (power) sum of these sources is calculated in Step 1c.

(2) The reverberant sound pressure level inside the pumproom (at the southeast wall) is then calculated (Embleton, 1971) from the sound power levels obtained in (1) above, the estimated room absorption characteristics, and the location of pump drive motors and compressors relative to the southeast wall. The results are presented as Steps 2 and 3 of Table 5.13.

(3) Next the outside sound pressure at the southeast wall is calculated (Gehring, 1978) using transmission loss values (for the wall) selected from measured values given in the following: Berendt, Winzer, and Burroughs, 1967; U.S. Army, 1968. The results are shown in Step 5 of Table 5.13. In turn, these intensities are multiplied by the wall area (log values summed) to yield the sound power given in Step 7.

(4) The sound pressure levels produced by this wall at the southeast property line are then calculated by subtracting the spreading loss (20 log distance) and adding 10 log $2\Pi(=8)$, in accordance with the standard propagation equation (Bolt Beranek and Newman, 1978). Results are tabulated in Step 9 of Table 5.13.

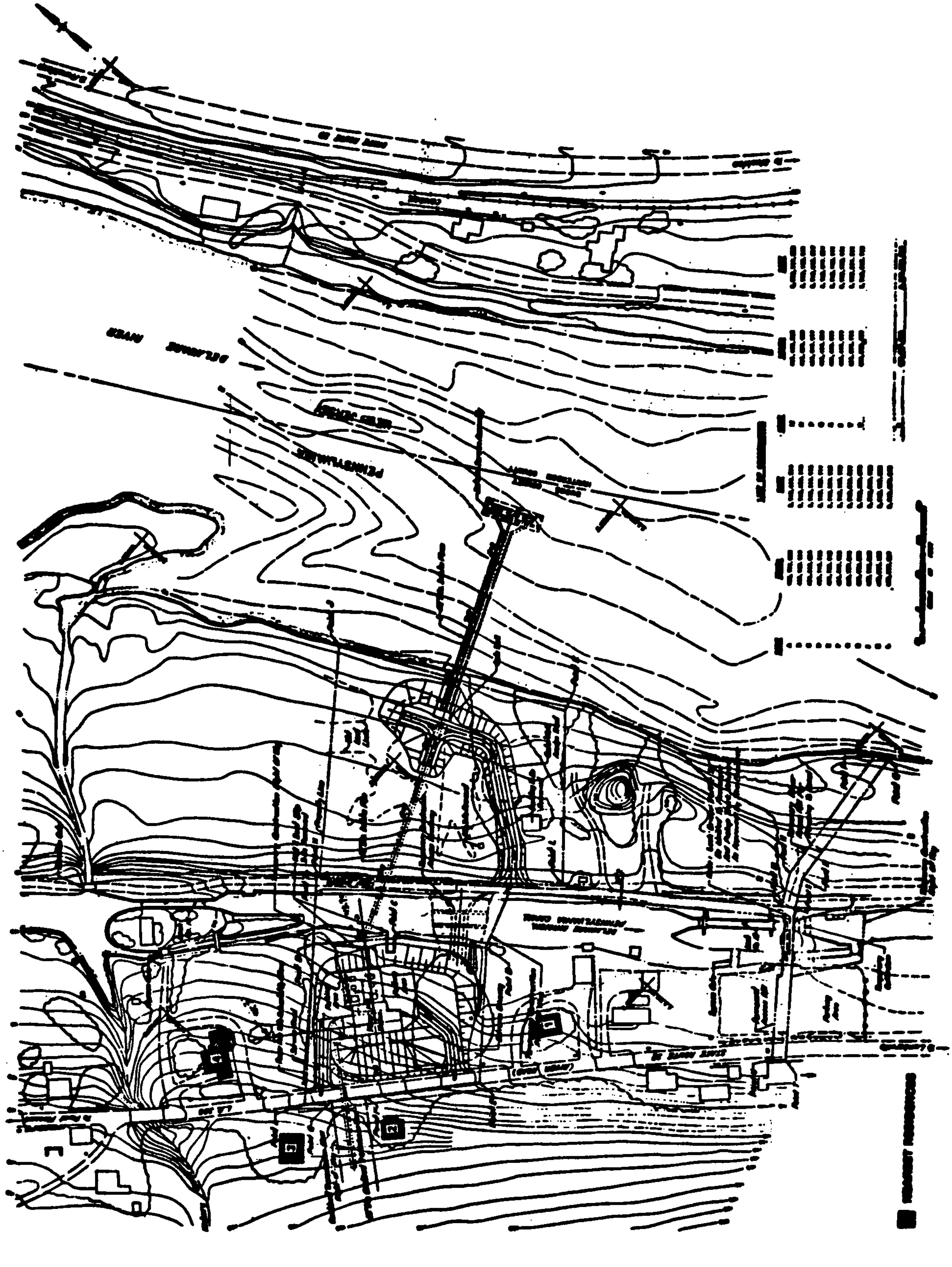

Figure 5.5 Location of Point Pleasant pumphouse, two transformers, and the four nearest residences

Table 5.13 Summary of calculations of noise impacts at southeast property line as a result of pump drive motor and compressor noise emissions through the southeast wall

Step	Octave Band Center Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
1a. Sound power of 3 pump motors (dB//1 pW)	90	91	91	91	101*	91	81	71
1b. Sound power of 2 compressors (dB//1 pW)	89	94	93	91	94	99	96	89
1c. Total sound power of interior sources (dB//1 pW)	92.5	95.8	95.1	94.0	101.8*	99.6	96.1	89.1
2. Correction for conversion to sound pressure level (dB)	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0
3. Interior sound pressure level (dB//20 μPa)	77.5	80.8	80.1	72.0	86.8*	84.6	81.1	74.1
4. Subtract TL + 6 (dB)	-48	-50	-54	-61	-66	-71	-74	-76
5. Exterior sound pressure level (dB//20 μPa)	29.5	30.8	26.1	18.0	20.8*	13.6	7.1	-1.9
6. 10 log[wall area] in m^2 (dB//1 m^2)	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1
7. Sound power of SE wall (dB//1pW)	48.6	49.9	45.2	37.1	32.9*	32.7	26.1	17.2
8. Subtract (20 log [37.19] plus 8)	-39.4	-39.4	-39.4	-39.4	-39.4	-39.4	-39.4	-39.4
9. Sound level at SE property line (dB//20 μPa)	9.2	10.5	5.8	- 2.3	0.5*	- 6.7	-13.3	-22.2

*Tonal components.

A comparison of the predicted sound pressure levels given in Step 9 with the masking level leads to the conclusion that there would be no perceptible impact at the southwest property line as a result of pump motor and compression noise emission through the southeast wall. The addition of a fourth pump and motor in the period 1990-2000 would not change the above conclusions.

5.12.1.2 Noise Emanating from the HVAC System

Analysis of the HVAC system openings to the outdoors indicated insignificant noise releases. Originally there was concern that noise would pass from the pumproom, back through the air inlet louvers, and to the outside with little attenuation. There was also concern that the path around the false wall to the outside in the direction of residences 2 and 3 (Figure 5.5) was short and not tortuous. However, a recent change in the design of the pumphouse relieves this concern. The design change calls for the false wall to be closed at the bottom. Air will enter at the top of the false wall and come into the pumproom through louvers near the bottom of the false wall. Thus, noise will be sufficiently attenuated because the design change will result in a noise path that is longer and more tortuous.

5.12.1.3 Noise Leaking from the Outside Doors

The third potential source of noise to the community is noise leaking through the crevices at the edges of the doors leading to the outside of the pumphouse. The applicant has stated that sound isolation of the double doors to the outside in the direction of the river exceeds STC-42,* and the sound isolation at the other three doors exceeds STC-25. The concrete walls of the pumphouse are equivalent to STC-55. Noise leaks through crevices between doors and door frames may be significant noise sources. However, these doors have weather stripping around the top, bottom, and sides that block the noise radiated from within the pumphouse. The calculations for noise from these sources are similar to those made for emissions from the walls, but with certain significant differences that are appropriate for movable "leaky" wall penetrations, such as doors, windows, and motor-operated vents that are manipulated frequently after their installation. The calculations are summarized in Table 5.14. The primary steps in these calculations are as follows:

(1) The same total power levels of pump drive motor and air compressor sources are used as in Table 5.13, Step 1c. Also, the same reverberant sound pressure levels are calculated and summarized as in Table 5.13, Step 3.

(2) Next sound transmission losses through the door with weather stripping are accounted for. The values of transmission loss for the weather-stripped door (Hedeen, 1980) are based on commercial products installed on standard doors. The values used correspond to the minimum overall performance indicated for the competing products listed. In this way, the STC-25 door with weather stripping mounted on the door has a combined set of transmission loss values corresponding to an STC-35 door. These transmission losses measured for a nominal STC-25 rating (American Society for Testing and Materials (ASTM) Standard E413-73) are subtracted in Step 4 of Table 5.14 to yield the results in Step 5.

*STC = Sound Transmission Class: a single number rating derived from measured values of sound transmission loss in accordance with ASTM Standard E413-73. It is an indication of the relative effectiveness of different doors, windows, and walls that provide sound insulation against noise that has most of its energy above 500 Hz. The higher the STC rating, the greater the noise isolation by the door, window, or wall.

Table 5.14 Summary of calculations of noise impacts at southeast property line as a result of emissions of pump drive motor and compressor noise through the exterior STC-35 single door (STC-25 door with weather stripping) mounted in southeast wall

	Octave Band Center Frequency (Hz)							
Step	63	125	250	500	1000	2000	4000	8000
1. Total sound power of interior sources (dB//1 pW)	92.5	95.8	95.1	94.0	101.8*	99.6	96.1	89.1
2. Correction for conversion to sound pressure level (dB)	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0
3. Interior sound pressure level (dB//20 μPa)	77.5	80.8	80.1	72.0	86.8*	84.6	81.1	74.1
4. Subtract TL+6(dB)	-15.0	-27.0	-39.0	-43.0	-39.0	-40.0	-45.0	-50.0
5. Exterior sound pressure level (dB//20 μPa)	62.5	53.8	41.1	36.0	47.8	44.6	36.1	24.1
6. 10 log [door area] in m^2 (dB//1 m^2)	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
7. SE wall door sound power (dB//1 pW)	65.2	56.5	43.8	38.7	50.5*	47.3	38.8	26.8
8. Subtract (8 + 20 log 37.19)	-39.4	-39.4	-39.4	-39.4	-39.4	-39.4	-39.4	-39.4
9. Sound level at SE property line (dB//20 μPa)	25.8	17.1	4.4	-0.7	11.1*	7.9	-0.6	-12.6
10. Ambient level - 3 (dB//20 μPa)	45	39	33	36	39	37	37	24
11. Correction for tone-masking level (dB)					-7**			
12. Tone masking level (dB//20 μPa)...subtract from tone level (in Step 9) to obtain audibility					32			
13. Audibility (dB)					-20.9			

*Tonal components predominate (see footnote to Table 5.13).
**10 log (bandwidth of octave band centered at 1000-Hz/critical bandwidth) = 10 log (724/161) ≅ 7 dB (Greenwood, 1961).

(3) In Step 6, the total emitting area of the door is added logarithmically (10 log area) to obtain the emitting sound power, which is summarized in Step 7.

(4) In Step 8, the sound pressure levels produced by the STC-25 single door at the southeast property line are calculated by subtracting the spreading loss (20 log distance) and adding 10 log 2π (=8), in accordance with the standard propagation equation of Bolt Beranek and Newman (1978). Results are finally tabulated in Step 9.

(5) The estimated nighttime ambient background sound pressure levels are obtained by subtracting 3 dB from the average daytime levels reported in Moiseev (1981), as discussed further below. The resulting values are entered as Step 10.

(6) Because the level of the emission in the 1000-Hz octave band (36 dB) consists primarily of tones from the pump drive motors, an additional check for their audibility is performed in Steps 11 through 13.

(7) The correction for the 1000-Hz octave band tone-masking level (7 dB) is subtracted in Step 11 from the nighttime ambient level in that band (Step 10) to obtain the threshold of tone audibility ("masking level"), 32 dB, in Step 12. The door-emitted sound pressure level of tones in that band given in Step 9 (11.1 dB) is below the masking level (32 dB) by 20.9 dB audibility, as listed in Step 13.

These results indicate, conservatively, that the rating of the door augmented by weather stripping is satisfactory to muffle any pump motor tones. The uncertainties of performance degradation caused by installation variables, wear, and maintenance would make it more desirable to use a prefabricated system (STC-35) with the seals installed in the factory. An STC-25 door without weather stripping, or seals that are inoperative because of long-term wear and tear, would not be satisfactory in muffling motor tones in the 1000-Hz band.

Calculations assuming four motors instead of three (the fourth installed after 1990) yield similar conclusions as above. The addition of one motor will cause the inside noise to increase by 20 log (4/3) = 1.2 dB. This increase is far below the noise level needed for audibility of pump motor tones in the 1000-Hz octave band.

5.12.1.4 Noise Radiated from the Two 7.5-MVA Transformers

A commitment by the applicant to purchase quieted transformers (NEMA rating 57 dBA) will reduce the noise impact, as compared to the applicant's earlier choice of unquieted transformers of NEMA rating 67 dBA. Calculations using the method of Foss (1976) for double barriers reveals that residences 2 and 3 (Figure 5.5) are sufficiently sheltered from the transformer noise; the tones from the transformers will not be audible at those residences.

Calculations for residence 4 (the more critical location of residences 3 and 4) reveal that annoying audible tones may remain at this residence even though quieted transformers are to be used at the site. The designated NEMA rating of 57 dBA provides information on the A-weighted sound pressure levels 1 m from the transformers. The NEMA rating unfortunately provides no information on the most important factor, i.e., the dB level for each of the four tones of the transformers: 120, 240, 360, and 480 Hz. These data are not provided unless a special request is made to the manufacturer to provide such data through special laboratory measurements. To provide an estimate of the adequacy of the transformers in terms of community noise impacts (adequacy is assured if no audible tones are present at the core frequencies at the site boundary), the NRC staff computed the sound pressure level at residence 4 from the two transformers, assuming that the transformer noise level is the lowest of any 7.5-MVA transformer noise level data that could be found in the published literature.

A compendium of perimeter data (measurements at 15-30 m (50-100 feet)) by Gordon et al. (1980) indicated that a Westinghouse 7.5-MVA transformer had measured core tones, adjusted to 152 m (500 feet), of 42 dB (120 Hz), 35 dB (240 Hz), 29 dB (360 Hz), and 26 dB (480 Hz). The NEMA sound level of this Westinghouse transformer may be estimated from Vér, Anderson, and Myles (1977) using data on the total surface area of the four sides of the Westinghouse transformer tank (Gordon et al., 1978) and the measured A-weighted sound level at 152.4 m (500 feet). The NEMA level computed was 47 dBA, which is 10 dBA lower than the NEMA rating for the transformers that the applicant plans to purchase for Point Pleasant. These Westinghouse transformer data represent the lowest noise emission of any 7.5-MVA transformer data that could be found in the published literature.

Table 5.15 presents the NRC staff's calculations of the noise level at residence 4 from the Westinghouse transformers assuming the following:

(1) The firewall between the two transformers acts as a barrier to one transformer, blocking radiation towards residence 4. However, the firewall acts as a perfect reflector to the other transformer, which faces residence 4.

(2) The nighttime noise levels at Point Pleasant are lower than the measured daytime levels by approximately 3 dB (a 5 dB reduction is perhaps more likely).

(3) The atmospheric attentuation from the transformers to residence 4 is negligible considering the short distances involved.

From Vér and Anderson (1977), the following inferences about community reaction can be made, based on the number of decibels by which each pure transformer tone exceeds the masking level (ΔL_{ex}):

$\Delta L_{ex} = 0$	complete masking, no complaints
$\Delta L_{ex} < 5$ dB	little likelihood of individual complaints
$5 < \Delta L_{ex} < 10$ dB	some likelihood of individual complaints
$\Delta L_{ex} > 10$ dB	strong likelihood of individual complaints

These criteria are based on experience with individual transformer tones in community settings. It is expected that group complaints may be triggered by values of ΔL_{ex} that are 3 dB to 5 dB higher than those listed above for estimating the reaction of individual residents.

Table 5.15 Summary of calculations of sound pressure levels and audibility of transformer tones at residence 4 in the vicinity of Point Pleasant pumphouse, dB

Sound Pressure Levels	120 Hz	240 Hz	360 Hz	480 Hz
Sound pressure level at 500 ft* for one transformer (Embleton, 1978)	42	35	29	26
Correction for distance to res 4				
$+20 \log \frac{500\ ft}{247\ ft}$	+6.1	+6.1	+6.1	+6.1
Correction due to sound reflection at firewall	+3.0	+3.0	+3.0	+3.0
Total	51.1	44.0	38.1	34.1
Tone Masking Levels	**125 Hz**	**250 Hz**		**500 Hz**
Ambient measured by Cerami & Assoc. (Moiseev, 1981)	42	36		39
Correction of ambient for nightime	-3	-3		-3
Total	39	33		36
Determination of Masking Levels (Vér and Anderson, 1977)	**120 Hz**	**240 Hz**	**360 Hz**	**480 Hz**
L_{mask}	L_{amb} (125 Hz) - 3 = 39-3 = 36	L_{amb} (250 Hz) - 6.5 = 33 - 6.5 = 26.5	0.5 [L_{amb}(250 Hz) + L_{amb}(500 Hz)] - 8 = 0.5(33 + 36) - 8 = 34.5 - 8 = 26.5	L_{amb} (500 Hz) - 9.5 = 36 - 9.5 = 26.5 db
Tone Audibility	**120 Hz**	**240 Hz**	**360 Hz**	**480 Hz**
ΔL_{ex}**	51.1 - 36 = 15.1	44.0 - 26.5 = 17.5	38.1 - 26.5 = 11.6	34.1 - 26.5 = 7.6

*To change feet to meters, multiply values shown by 0.3048.
**Transformer tone sound pressure level minus masking level.

As can be seen from Table 5.15, the 240-Hz tone is 17.5 dB above masking level. Assuming that individual complaints are likely at 5 dB above masking level, it appears that a reduction of 12.5 dB is required to prevent the likelihood of complaints, and a reduction of 17.5 dB is required to avoid the audibility of tones at residence 4. Similar numbers may be obtained for tones at 120, 360, and 480 Hz using the numerical data from Table 5.15.

All tones are computed to be audible at residence 4. A reduction in NEMA level (67 dBA to 57 dBA) for the Point Pleasant transformers will result, at most, in a 10-dB reduction in each tone. It appears very likely then that the use of a quieted transformer alone will not ensure that transformer tones at residences 3 and 4 will be inaudible.

5.12.2 Noise Impacts at the Bradshaw Reservoir Pumping Station

Two types of acoustic sources must be analyzed in evaluating noise impacts to the community because of the Bradshaw reservoir pumping station. The first source category is the pumphouse building itself. Most of the noise intensity within the building comes from the vertical motors driving the four vertical-turbine, multistage pumps. The individual motor sound level limit is specified to be 86 dBA at 1 m, as measured in accordance with IEEE Standard 85. As the walls are presently designed, the high attenuation (greater than 45 dBA) of the 8-in.-thick precast concrete walls makes any noise transmission through those walls insignificant. However, the noise radiated from the two ventilation air inlet openings without interior ducts located on the northeast (reservoir) side of the building must be considered. The tonal components of the pump drive motor noise are likely to be concentrated in the 1000-Hz octave band, and they must be analyzed for audibility at the nearest line-of-sight residences. These residences are directly across the reservoir, along Point Pleasant Pike (Figure 5.6). The water in the reservoir acts as an essentially perfect reflector to incident noise. In addition, noise from the four vaneaxial ventilation exhaust fans is radiated from the roof-mounted ventilators. These latter sources of noise must be analyzed for noise impact at the nearest residences along Moyer Road.

The second potentially significant noise source category is that of the two transformers located just outside the northwest wall of the building. Transformers are tonal sources, and the audibility of tones at 120, 240, 360, and 480 Hz frequencies must be evaluated for locations at the nearest residences.

A sketch of the area in the vicinity of the pumphouse, which shows the locations of the nearest residences, is given in Figure 5.6.

5.12.2.1 *Noise Impacts from the Pumphouse Building*

<u>Impact of Noise from the Pumphouse Intake Ventilation Louvers</u>

As noted earlier, there is a potential impact from noise being emitted from the four air-intake louvers located on the northeast wall of the building.

Interior sound pressure levels are calculated from sound power specified by the manufacturer for the four vaneaxial ventilation fan intakes and for the four vertical pump drive motors by the model given in Bolt Beranek and Newman (1978). The sound power levels radiated by the four ventilation intake louvers (when open) on the northeast (reservoir) side of the building are listed in Table 5.16.

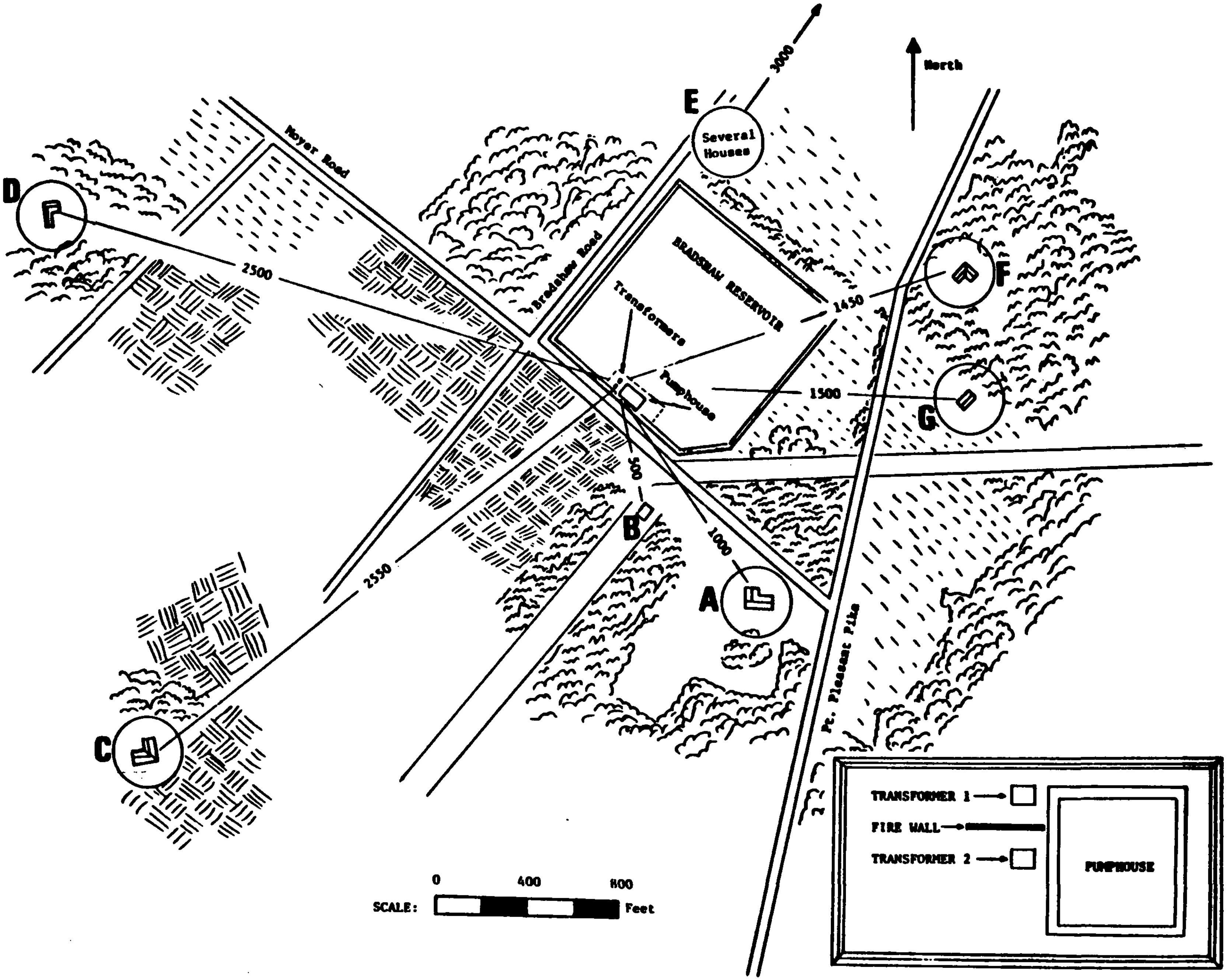

Figure 5.6 Environs of Bradshaw pumping station, including relative locations of pumphouse building, transformers, and nearest residences

Table 5.16 Summary of calculations of noise impacts at residence F in the vicinity of Bradshaw pumping station due to ventilation intake louver emissions resulting from pumphouse drive motor noise and vaneaxial ventilation fan intakes

	Frequency (Hz)							
Step	63	125	25	500	1000	2000	4000	8000
1a. Sound power of 4 pump motors (dB//1 pW)	91	92	92	92	102*	92	82	72
1b. Sound power of 4 fan intakes (dB//1 pW)	74	78	80	75	74	67	60	58
1c. Total sound power of interior sources (dB//1 pW)	91	92	92	92	102*	92	82	72
2. Total exterior sound power of vent louvers (dB//1 pW)	79	79	80	80	88*	76	66	54
3. Corr. for 1450 ft**	-62	-62	-62	-64	-65	-69	-77	-87
4. Sound pressure level at res. F (dB//20 μPa)	17	17	18	16	23*	7	-11	-33
5. Subtract tone-masking level of res ambient (dB//20 μPa)					-14			
6. Audibility above tone masking level (dB//20 μPa)					9*			

*Tonal components predominate.
**To change feet to meters, multiply value shown by 0.3048.

The nearest line-of-sight residences are at locations F and G, across the almost perfectly reflecting surface of the reservoir water. For the nearest residence at F (442 m (1450 feet) distant), the estimated sound pressure levels as a result of emissions from open ventilation intake louvers also are indicated in Table 5.16. The total sound pressure level of drive motor tones concentrated within the 1000-Hz octave band is indicated to be approximately 9 dB greater than the masked threshold of audibility produced by residual nighttime ambient level. Thus, all intake louvers must be equipped with duct attenuators or with attenuating louvers to provide insertion loss in the 1000-Hz octave band that is sufficient to reduce the level of tones within that band to less than 5 dB. The steps in the NRC staff calculations are as follows:

(1) The sound power levels of the four pumps and four vaneaxial ventilation-fan intakes are calculated. These power levels are summarized in Step 1c of Table 5.16.

(2) The reverberant level inside the pumproom is then calculated (Embleton, 1971) from the sound power levels obtained from (1), the estimated room absorption characteristics, and the relative location of the pump drive motors with respect to the louvers. Computed next is the drop in sound pressure level to the outside because of the open louvers (Vér and Anderson, 1977). The results of this computation are presented as Step 2 in terms of the sound power level of an equivalent noise source outside the open louvers (outside the pumphouse).

(3) A calculation is then made to account for the distance and atmospheric attenuation as a result of the relative positions of this "new" outside noise source and residence F. The results appear in Step 3 (as a correction) (Bolt Beranek and Newman, 1978).

(4) The sound pressure levels at residence F are computed in Step 4 by summing lines (2) and (3).

(5) The tone-masking level of the residential nighttime ambient noise in the 1000-Hz octave band is given in Step 5.

(6) The audibility of the tones in the 1000-Hz octave band is given in Step 6.

It can be seen that 9 dB of additional attenuation is required in the 1000-Hz octave band to ensure that the pump drive motor tones are inaudible. Presently two louvers open directly into the pumproom. The other two louvers are equipped with two acoustically lined ducts that conduct the outside air from the louvers into the pumproom. The sound attenuation through these two ducts as presently designed is approximately 19 dB in the 1000-Hz octave band. Installation of vertical duct attenuators in all four louver systems would reduce noise emitted in the 1000-Hz octave band by approximately 16 dB. If this is done, there will be no audibility of the 1000-Hz band tones. The applicant has committed to make this modification to the ventilation louvers (Boyer, 1983).

Impact of Noise from Ventilation Fan Exhausts Through the Pumphouse Roof Ventilators

The other potentially significant source of sound emitted from the pumphouse structure is the noise of the four vaneaxial ventilation fan exhausts through the four roof-top ventilators. The sound power levels calculated for these sources are listed in Table 5.17. Residence B is the nearest essentially line-of-sight location at 152 m (500 feet) from these ventilators. The estimated sound pressure levels at this location due to these roof ventilators are also indicated in Table 5.17, along with typical rural residual ambient sound pressure levels (EPA, 1971). It is obvious that no impact exists because the calculated levels due to roof ventilator emissions are well below the assumed ambient levels.

Table 5.17 Summary of calculations of noise impacts at residence B in the vicinity of the Bradshaw pumping station due to roof ventilator emissions from vaneaxial fan exhaust noise

	Frequency, Hz							
Step	63	125	250	500	1000	2000	4000	8000
Sound power from 4 roof ventilators (dB//1 pW)	67	72	67	55	42	40	35	35
Correction for 500 ft*	-51	-51	-51	-52	-52	-54	-57	-60
Sound pressure level at res. B (dB//20 μPa)	16	21	16	3	-10	-14	-22	-25
Typical rural night-time sound levels (dB//20 μPa)	36	36	28	23	21	17	13	9

*To change feet to meters, multiply values shown by 0.3048.

Summary

Based on the assumptions applied and the analysis above, the NRC staff concludes for the Bradshaw Reservoir pumphouse that

(1) Significant noise is radiated from the pump motors through two louvers without interior ducts on the northeast wall of the pumphouse. Audible motor tones may be heard at residences F and G, at levels likely to cause complaints (i.e., greater than 5 dB audibility). Vertical duct attenuators should be installed in all four louver systems. If the design presently specified for two of the louver systems were used for all four, as committed to by the applicant, it would reduce tone emission in the 1000-Hz octave band by approximately 16 dB. This level of tonal reduction in the 1000-Hz octave band would ensure inaudibility of that tone at residences F and G.

(2) Noise radiated from the vaneaxial fans through the exhaust duct and roof ventilators is well below residual ambient levels and, therefore, is insignificant.

5.12.2.2 Noise Impact of Transformers

As shown in Figure 5.6, the nearest residence (residence B) is about 152 m (500 feet) southeast of the pumphouse and is sheltered from the direct line of sight of the transformers. The pumphouse structure will act as a barrier and will attenuate the noise of the transformers to a large degree. Residence A is also sheltered from the transformer noise by the pumphouse structure, but is further away than B and will be impacted less by transformer noise. Residences C through

G are in a complete or partial line of sight of the transformers. However, the distances (442 to 914 m (1450 to 3000 ft)) from the transformers for these residences are much greater. Attenuation as a result of hemispherical spreading (reduction in noise with distance from source), atmospheric attenuation, and attenuation because of the presence of trees are other important factors for these residences that are further away.

Ambient noise measurements for the site are scant. Available noise readings in the project area may be found in the environmental report on the Nashaminy Water Supply System (NWRA, 1979). Readings vary from 43-51 dB. Details on how and when the measurements were taken are not presented in that report, nor is information given on sound pressure levels at the site during the most sensitive period; i.e., during sleeping hours between midnight and 4 a.m. In fact the A-weighted sound levels measured are not useful in calculations to determine if the transformer tones are audible at the nearest residences. Needed instead are the octave-band sound pressure levels as a result of the ambient broadband noise. The sound pressure levels are used to determine the masking level at each transformer core-tone frequency. In this analysis, the staff used an average of measured octave-band sound pressure level data for rural areas published in an EPA report (EPA, 1971). These data indicate that for rural areas similar to the vicinity of the Bradshaw pumping station, a typical nighttime residual sound pressure level spectrum would be

63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
35.9 dB	35.7 dB	27.9 dB	23.1 dB	20.9 dB	17.1 dB	12.6 dB

This corresponds to an A-weighted sound pressure level of 27 dBA.

The applicant did not know the octave-band sound power levels for the two transformers at Bradshaw. The transformers have a 2.5-MVA equivalent two-winding (ETW) rating. The NRC staff is not aware of any published data for 2.5-MVA transformers, but perimeter data for small, medium, and large-sized transformers (7.5 - 486 MVA) were reported by Gordon et al. (1980). Perimeter data here refer to averages of sound pressure level measurements made around a circle with a radius of 15 to 30 m (50 to 100 feet) from the transformers. In Gordon et al. (1980), empirical correlations were developed that can be used to estimate the sound pressure level at each of the transformer core-tone frequencies at a distance 152 m (500 feet) from a transformer. The empirical correlations are given on p. 17 (Table 7) of Gordon et al. (1980). Using those formulas, sound pressure levels at a distance of 152 m (500 feet) for each 2.5 MVA transformer are as follows:

120 Hz	240 Hz	360 Hz	480 Hz
43.6 dB	31.4 dB	22.2 dB	18.3 dB

Adjustments should be made for distances other than 152 m (500 feet) based on the following:

(1) Reduction in noise level with distance as a result of the effect of hemispherical spreading of noise from the source.

(2) Atmospheric attenuation (molecular adsorption plus anomalous excess attenuation) that occurs between the distance of interest and 152 m (500 feet).

(3) Attenuation because of trees that may be present between the transformer and the residences.

(4) The effects of the pumphouse structure as a barrier to the noise propagation. The staff used the method of Foss (1976), which is based on laboratory data on the noise-reduction of double barriers. In this method, the paths of noise over and around the sides of the pumphouse are taken into account.

•The residences may be divided into three classes as follows:

(1) Residences A and B are closest to the transformers but are shielded by the pumphouse, which acts as a barrier to noise propagation. Residence B is more critical than A because it is closer to the transformers. Predictions of noise levels at B are given in Table 5.18. The pumphouse provides significant attenuation to the transformer tones but not enough to make the 120-Hz tone inaudible. The 120-Hz tone is 1.2 dB above the masking level for that tone. Calculations for residence A (305 m (1000 ft) from the transformers) indicate that the tones will be inaudible at that site.

The noise due to the transformers will be audible at the 120-Hz tone because the masking level at the core tone is lower than the noise contribution due to the transformer. According to Vér and Anderson (1977), there is little likelihood of complaints at B because the difference between the transformer noise at the core tone and the masking level at the tone is less than 5 dB.

(2) Residences C, D, and E are not shielded by the pumphouse and are in the direct line of sight of the two transformers. Site D was chosen to represent this group because it is a short distance from the transformers. Predictions for site D are given in Table 5.19. Conservative assumptions are made that the firewall (2.4 m (8 feet) high) between the transformers totally reflects the incident sound energy, and that constructive interference occurs at locations C and E. It is also conservatively assumed for location D that those same conditions apply that add 6 dB to each core-tone level of one transformer. Predictions for site D indicate that the 120-Hz transformer tone will be audible but that it is not likely to cause individual complaints.

The noise due to the transformers will be audible at the 120-Hz tone because the masking level at that core tone is lower than the noise contribution due to the transformer. According to Vér and Anderson (1977), there is little likelihood of complaints at B because the difference between the

Table 5.18 Summary of calculations of noise impacts at residence B in the vicinity of the Bradshaw pumping station due to transformers, dB

Noise Contribution	120 Hz	240 Hz	360 Hz	480 Hz
Single transformer, sound pressure level*	43.6	31.5	22.2	18.3
Addition due to second transformer**	+ 6.0	+ 6.0	+ 6.0	+ 6.0
Attenuation due to pumphouse as barrier***	-14.9	-17.1	-18.7	-20.0
Attenuation due to 15 m of trees†	- 0.8	- 0.9	- 1.2	- 1.2
Total	33.9	19.5	8.3	3.1
Masking Levels due to Ambient Noise at Each Transformer Core-Tone††	**120 Hz**	**240 Hz**	**360 Hz**	**480 Hz**
L_{mask}	L_{amb} (125 Hz) - 3 = 35.7 - 3 = 32.7	L_{amb} (250 Hz) - 6.5 = 27.9 - 6.5 = 21.4	0.5 [L_{amb} (250 Hz) + L_{amb} (500 Hz)] - 8 = 25.5 - 8 = 17.5	L_{amb} (500 Hz) - 9.5 = 23.1 - 9.5 = 13.6

*These sound pressure levels have been generated for a distance of 152 m (500 ft) from the transformer source (Gordon et al., 1980).

**This 6-dB addition (instead of the usual 3-dB addition due to a second identical source) assumes a perfectly reflecting firewall barrier with noise in phase (coherence of noise source and its reflected energy) at the receptor.

***The method of Foss (1976) is used, assuming residence B is on the side of the pumphouse opposite the transformers.

†An "average trees" thickness of 15 m blocking the line of sight is assumed here (Bolt Beranek and Newman, 1978).

††Foss, 1976.

Table 5.19 Summary of calculations of noise impacts at residence D in the vicinity of the Bradshaw pumping station due to transformers, dB

Noise Contribution	120 Hz	240 Hz	360 Hz	480 Hz
Single transformer sound pressure level (500 ft)*	43.6	31.5	22.2	18.3
Addition due to second transformer	6.0	6.0	6.0	6.0
Adjustment to 2500 ft (attenuation due to distance)	-14.0	-14.0	-14.0	-14.0
Atmospheric attenuation between 500 ft and 2500 ft	- 1.6	- 2.4	- 2.9	- 3.6
Total	34.0	19.1	11.3	6.7
Masking Levels due to Ambient Noise at Each Transformer Core-Tone**	**120 Hz**	**240 Hz**	**360 Hz**	**480 Hz**
L_{mask}	32.7	21.4	17.5	13.6

*To change feet to meters, multiply values shown by 0.3048.

**Foss, 1976.

transformer noise at the core tone and the masking level at the tone is less than 5 dB.

(3) Residences at F and G are partially shielded from the transformers by the pumphouse. Only one of the two transformers is in the line of sight of the residences. The other is shielded by the pumphouse structure and will make no significant noise contribution. The conservative assumption is made that F and G receive the effects of one transformer and its totally reflecting firewall.

It is assumed, conservatively, for calculations for residence F that

- Transformer 1 radiates directly to location F including a totally reflecting firewall.
- Transformer 2 is sufficiently sheltered by the pumphouse structure and firewall so that its influence is negligible.

As seen in Table 5.20, the 120- and 240-Hz tones will be audible by 4.6 and 3.0 dB, respectively.

Based on the assumptions applied and the analysis given above, the NRC staff concludes that transformer core tones may be audible at residential sites B, D, and F. The NRC staff calculations indicate that there is little likelihood of complaints from these residences. However, the NRC staff does not have precise knowledge of the transformer core tone levels and the residual ambient for the site. The NRC staff calculations, therefore, are best estimates of the expected community response based on the very limited information available for the Bradshaw pumping station site.

5.12.2.3 Noise Radiation Through Pumphouse Walls, Doors, and Roof

Radiation of noise through the southeast and southwest walls was calculated to ascertain that there is a negligible increase in noise at the location of the nearest residence, B. The methodology of calculation is identical to that used and described earlier for the Point Pleasant pumphouse walls. The steps in Table 5.21 are essentially identical to the steps in Table 5.13. As can be seen, there is no problem with noise increase as a result of the walls because the noise transmission through the pumphouse walls is negligible compared to the ambient assumed for the site.

Radiation of noise through the STC-25 double door in the southeast wall was calculated to determine if audible pump motor tones in the 1000-Hz frequency band occur at residence B (see Table 5.22). The STC-25 double door planned will be sufficient to cause the tone to be inaudible at that residence because of the weather stripping added around the door edges. Without that added weather stripping, STC-25 double doors would not be sufficient to block the tonal components from the motors through the crevices between the door and door frame. The calculational method is exactly the same as used in the Point Pleasant case, and the staff's conclusions are identical. The weather stripping planned should be sufficient to prevent annoying tones from being present at residence B. As of the date of this analysis (May 1983), no commercial brand of weather stripping has been identified by the applicant. When this decision is made, the NRC staff will check the transmission loss characteristics of the weather stripping/door combination to ensure that no change in conclusions should be made in this regard. The NRC staff also will verify the presence of significant motor tones when the final decision on pump motor manufacturer is announced.

Radiation of noise from the roof leads to a marginally acceptable noise impact at residence B. Calculations of noise loss through the roof were made in the same way as they were for noise through the doors, but with one exception. For the roof, there is a vertical directivity effect because of the elevation difference between the pumphouse roof and residence B. That directivity was chosen conservatively (Step 8 in Table 5.23). Based on the staff's calculations, a tone audibility 2 dB above masking level is predicted to occur at residence B. This increase should not be noticed by the residents.

5.12.3 Noise Impacts at the Limerick Site

The major noise sources at the Limerick site are

Table 5.20 Summary of calculations of noise impacts at residence F in the vicinity of the Bradshaw pumping station due to transformers, dB

Noise Contribution	120 Hz	240 Hz	360 Hz	480 Hz
Single transformer sound pressure level (500 ft)*	43.6	31.5	22.2	18.3
Addition due to second transformer	+ 6.0	+ 6.0	+ 6.0	+ 6.0
Adjustment to 1450 ft (attenuation due to distance)	- 9.2	- 9.2	- 9.2	- 9.2
Atmospheric attenution between 500 ft and 2500 ft	- 0.1	- 0.2	- 0.2	- 0.2
Attenuation due to 60 m of trees	- 3.0	- 3.7	- 4.3	- 4.9
Total	37.3	24.4	14.5	10.0
Masking Levels due to Ambient Noise at Each Transformer Core-Tone**	**120 Hz**	**240 Hz**	**360 Hz**	**480 Hz**
L_{mask}	32.7	21.4	17.5	13.6

*To change feet to meters, multiply values shown by 0.3048.

**Foss, 1976

(1) two natural draft cooling towers

(2) six main generator step-up (GSU) transformers--three for Unit 1 and three for Unit 2

(3) two unit auxiliary transformers

(4) two safeguard transformers

The noise from the cooling towers comes from the falling water inside the tower; this noise is emitted from both the stacks and rims of the cooling towers and is broadband in nature. The noise from the transformers, however, has tones at 120, 240, 360, and 480 Hz frequencies. These tones must be considered separately from the broadband contribution. The different character of this noise (tonal versus broadband) requires a special analysis to determine its audibility and community impact. Other noise sources at the site lead to insignificant

Table 5.21 Summary of calculations of noise impacts for residence B in the vicinity of the Bradshaw pumping station due to emission of interior equipment noise through the southeast and southwest walls

Step	Frequency, Hz							
	63	125	250	500	1000	2000	4000	8000
1. Total sound power level of interior sources (dB//1 pW)	91	92	92	92	102*	92	82	72
2. Correction for interior pressure level at SE wall (dB//20 μPa)	-13	-13	-13	-13	-13	-13	-13	-13
3. Interior sound pressure level at ceiling (dB//30 μPa)	78	79	79	79	89*	79	69	79
4. Subtract transmission loss of wall** + 6	-40	-42	-44	-49	-56	-62	-67	-72
5. Exterior sound pressure level (dB//20 μPa)	38	37	35	30	33*	17	2	-13
6. 10 log (SE +SW wall area)	22	22	22	22	22	22	22	22
7. Sound pressure level of walls (dB//1 pW)	60	59	57	52	55*	39	24	9
8. Correction for 500 ft*** to res B	-51	-51	-51	-52	-52	-54	-57	-60
9. Sound pressure level at res B (dB//20 μPa)	9	8	6	0	3*	-15	-30	-51
10. Nighttime residual ambient level (dB//20 μPa)	36	36	28	23	21	17	13	11
11. Subtract tone-masking level of ambient noise (dB//20 μPa)					-14			
12. Tone audibility at residence B (dB)					-11			

*Tonal components predominate.

**U.S. Department of the Army, 1968.

***To change feet to meters, multiply the value shown by 0.3048.

Table 5.22 Summary of calculations of noise impacts at residence B in the vicinity of the Bradshaw pumping station due to emmission of interior equipment noise through the exterior STC-35 double-door (STC-25 door with weather stripping) mounted in the southeast wall

	Frequency, Hz							
Step	63	125	250	500	1000	2000	4000	8000
1. Total sound power of interior sources (dB//1 pW)	91	92	92	92	102*	92	82	72
2. Correction for conversion to sound pressure level (dB//1 pW)	-13	-13	-13	-13	-13	-13	-13	-13
3. Interior sound pressure level (dB//20 μPa)	78	79	79	79	89*	79	69	59
4. Subtract TL + 6(dB)	-15	-27	-39	-43	-39	-40	-45	-50
5. Exterior sound pressure level (dB//20 μPa)	63	52	40	36	50	39	24	9
6. 10 log [door area] in m^2 (dB//1 m^2)	6	6	6	6	6	6	6	6
7. SE wall door sound power (dB//1 pW)	69	58	46	42	56*	45	30	15
8. Correction for 500 ft*** to res B	-51	-51	-51	-52	-52	-54	-57	-60
9. Sound pressure level at res B (dB//20 μPa)	18	7	-5	-10	-4*	-9	-27	-45
10. Nighttime residual ambient level (dB//20 μPa)	36	36	28	23	21	17	13	11
11. Correction for tone-masking level					-7**			
12. Tone masking level (dB//20 μPa)... subtract from the tone level (Step 9)					14			
13. Tone audibility at res B (dB)					-10			

*Tonal components predominate.
**10 log (bandwidth of octave band centered at 1000 Hz/critical bandwidth) = 10 log (724/161) ≅ 7 dB.
***To change feet to meters, multiply the value shown by 0.3048.

Table 5.23 Summary of calculations of noise impacts for residence B in the vicinity of the Bradshaw pumping station due to emission of interior equipment noise through the roof

	Frequency, Hz							
Step	63	125	250	500	1000	2000	4000	8000
1. Total sound power level of interior sources (dB//1 pW)	91	92	92	92	102*	92	82	72
2. Correction for interior pressure level at ceiling (dB//20 μPa)	-12	-12	-12	-12	-12	-12	-12	-12
3. Interior sound pressure level at ceiling (dB//20 μPA)	79	80	80	80	90*	80	70	60
4. Subtract transmission loss of roof deck** + 6	-17	-23	-28	-32	-36	-41	-47	-52
5. Exterior sound pressure level (dB//20 μPa)	62	57	52	48	54*	35	23	8
6. 10 log [roof area]	24	24	24	24	24	24	24	24
7. Sound power level of roof (dB//1 pW)	86	81	76	72	78*	63	47	32
8. Directivity index for location at res B (dB)***	-3	-4	-6	-8	-10	-12	-14	-16
9. Correction for 500 ft† to res B	-51	-51	-51	-52	-52	-54	-57	-60
10. Sound pressure level at res B (dB//20 μPa)	32	26	19	12	16	-3	-24	-44
11. Nighttime residual ambient level (dB//20 μPa)	36	36	28	23	21	17	13	11
12. Subtract tone masking level of ambient noise (dB//20 μPa)					-14			
13. Tone audibility at res B (dB)					2			

*Tonal components predominate.
**Egan, 1972.
***U.S. Department of the Army, 1968.
†To change feet to meters, multiply the value shown by 0.3048.

contributions to community noise levels because of their presence within buildings, the intermittent nature of some source, or the low sound power level of other sources. The relatively large distances from these sources to the nearby sensitive areas further underscores the negligible contribution from these sources.

Ambient measurements at the site were made in 1973 by Techtel Inc. (Lou, 1973), for the applicant. The NRC staff chose the ambient at measuring points 3 and 10 (Figure 5.7) as most representative of the site vicinity. The octave band sound levels at point 3 are measures at 2:45 a.m. on June 13, 1973. This time (2:45 a.m.) represents a sensitive time when residents are in bed. Point 10 was of interest because its ambient in the 250-Hz octave band was quite low.

Acomputer model (Dunn et al., 1983) based largely on the Edison Electric Institute (EEI) Environmental Noise Guide (1978) was used to predict the effect of plant noise at the foure nearest receptors. The two natural draft cooling towers and all transformers were assumed to be in operation continuously, throughout the day and night. Standard day conditions (18°C ambient temperature and 70% relative humidity) were also assumed.

Source data on the natural draft cooling tower noise came from the EEI Noise Guide (Dunn et al., 1982). Noise from the two transformers was more difficult to model. All transformers are sheltered by the firewalls, and a separate analysis had to be made as to the effect of reflection and diffraction of noise around those firewalls. Sound absorption masonry is used to quiet the main transformers. The effect of the sound absorption was included in the determination of the sound power level of each transformer. For the purpose of calculation of far field noise at the nearest residences, each transformer noise source was replaced by an "equivalent" source for which the effect of the fire-walls and sound-absorption masonry had already been included. That procedure is valid for calculations at large distances as applies here. A virtual source is required for each one to account for noise reflections from the turbine building itself. Figure 5.8 shows with an "X" the location of the generator step-up transformers considered in the NRC staff calculation and with a "V" the location of the virtual source for each corre-sponding "X".

The results of the NRC staff model predictions are

(1) If the measured ambient at location 10 of the site survey (June 1973) is representative of the area in the vicinity of the residences A and B off Sanatoga Road, then the transformer tones will be audible at those residences. Because the tones are, in general, less than 5 dB above the masking level of the "effective broadband ambient" there, no significant number of individual compliants of annoyance may be expected. If the ambient measured at location 3 (June 1973 survey) is representative, the 120-Hz and 240-Hz transformer tones will be barely audible and are not expected to be a cause of annoyance to the residents.

(2) The presence of the cooling towers enhances the broadband ambient at residences A and B (also C and D). The enchanced broadband noise at these residences is not sufficient to be annoying. Interestingly, the presence of this enhanced broadband noise is sufficient to mask the transformer

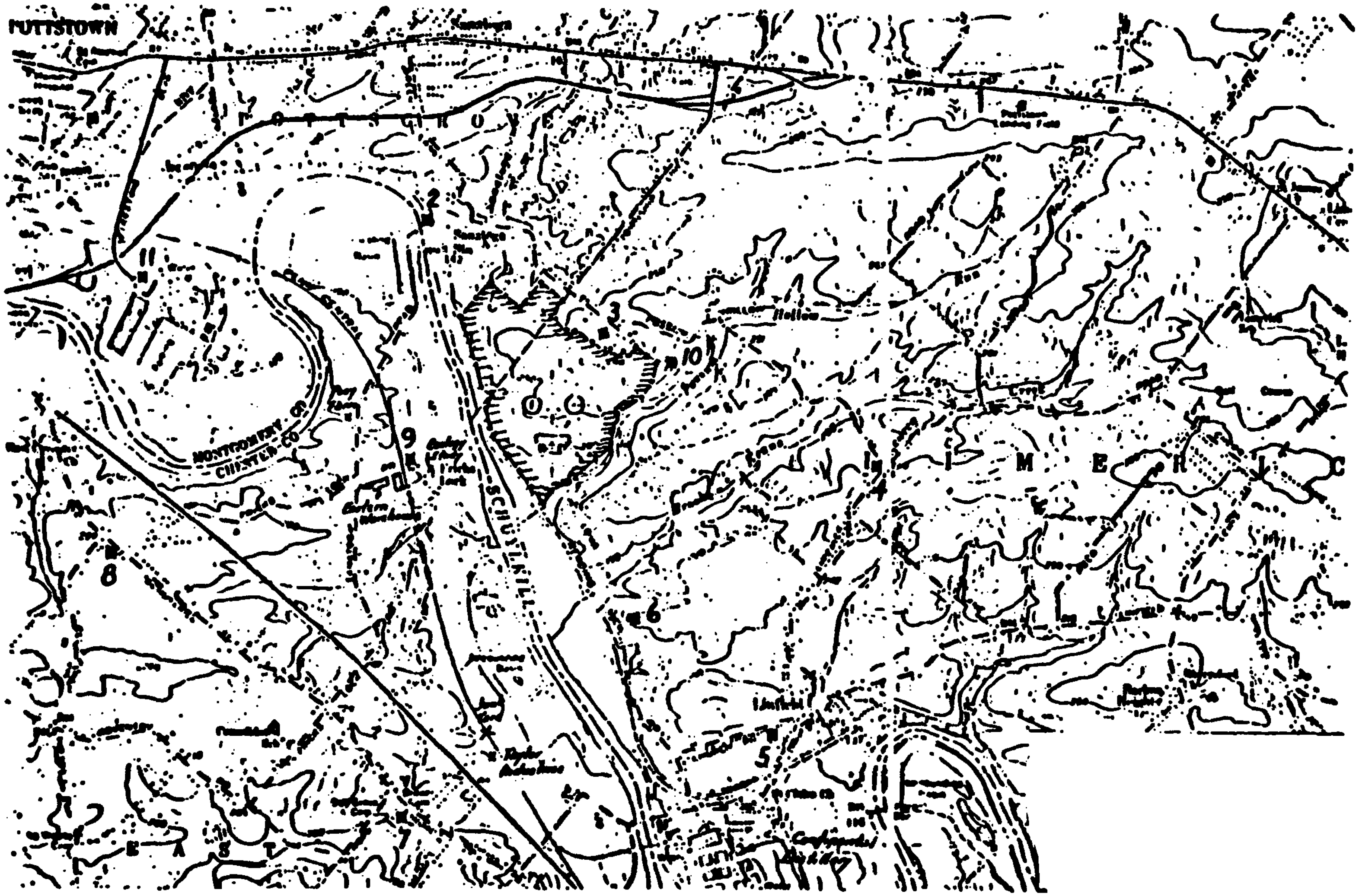

Figure 5.7 Sketch of ambient measurement locations from Lou, 1973 (Measurement point 3 and 10 are used in this analysis.)

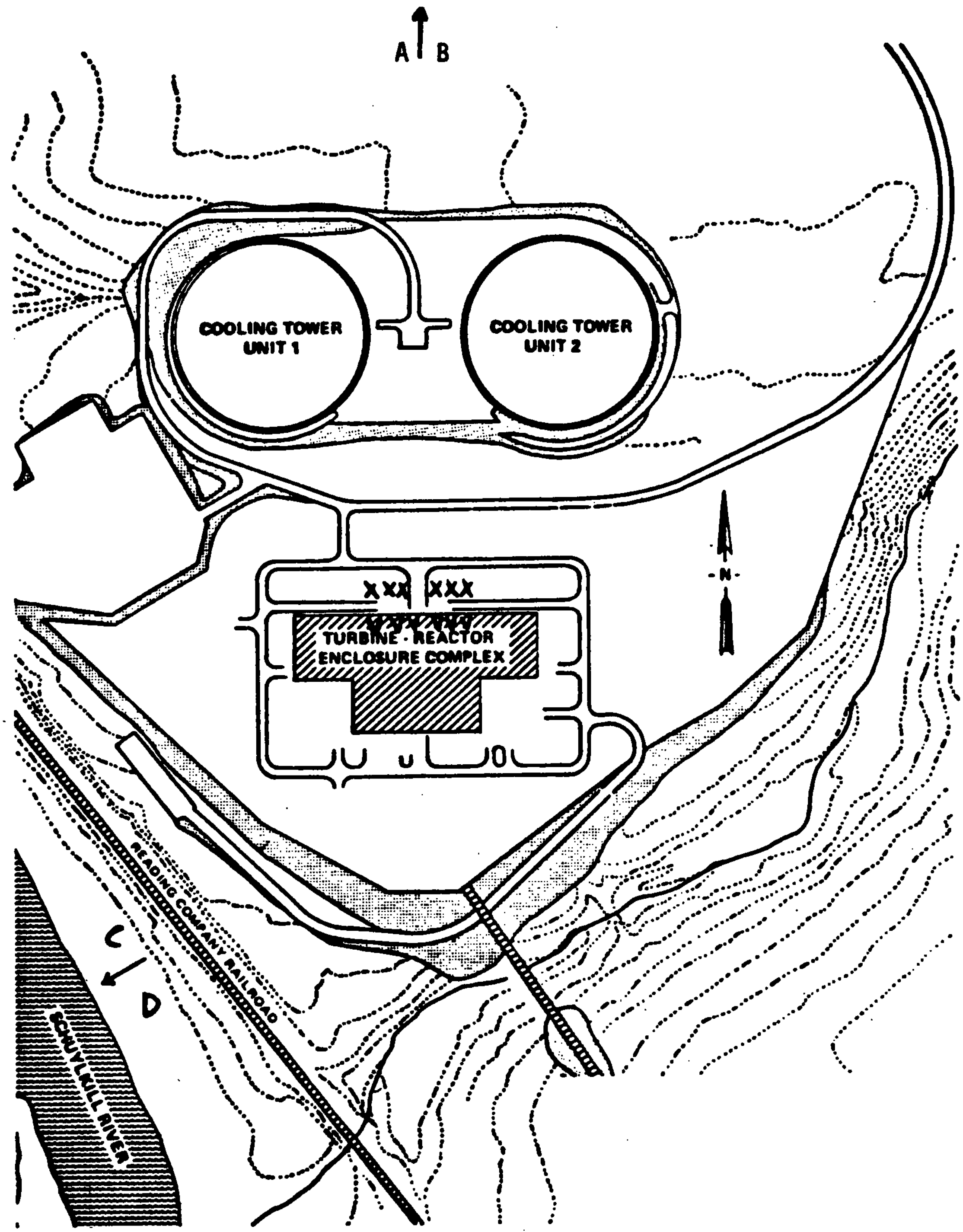

Figure 5.8 Sketch of relative positions of cooling towers, generator step-up transformers, and nearest residences at Limerick.

Note: Residences A and B are located in the vicinity of the intersection of Sanatoga Rd. and Evergreen Rd. Residences C and D are located across the Schuylkill River along Fricks Lock Rd. and the Conrail Railroad track, respectively.

tones to a level that does not lead to annoying audible tones. Without the cooling tower noise, the "natural" ambient is not sufficient to mask the transformer tones. In such case, the tones would annoy the residents (calculations not shown). Fortunately, the transformers and cooling towers are in operation simultaneously.

(3) The calculations reveal that if the measured ambient at location 10 is a valid representation of the ambient at residences A and B, a potential problem exists with respect to audible transformer tones. The accuracy of the present calculations is not sufficient for the NRC staff to make definitive conclusions on this matter. Some of the uncertainties are

- the precise sound power levels of the transformers
- the precise effect of the firewalls and reflection from the turbine building
- the presence of isolated trees in reducing the noise propagation to residences A and B
- the equivalence of the noise spectrum at location 10 to that at residences A and B

Monitoring and mitigative action, if necessary, as indicated in Section 5.14.4.3, should be undertaken.

5.13 Emergency Planning Impacts

In connection with the promulgation of the Commission's upgraded emergency planning requirements, the NRC staff issued NUREG-0658, "Environmental Assessment for Effective Changes to 10 CFR Part 50 and Appendix E to 10 CFR Part 50; Emergency Planning Requirements for Nuclear Power Plants." The staff believes the only noteworthy potential source of impacts to the public from emergency planning would be associated with the testing of the early notification system. The test requirements and noise levels will be consistent with those used for existing alert systems; therefore, the NRC staff concludes that the noise impacts from the system will be infrequent and insignificant.

The emergency operations facility will be located in an existing Philadelphia Electric Company service building; therefore, its construction will not involve any environmental impacts.

5.14 Environmental Monitoring

5.14.1 Terrestrial Monitoring

Studies of the terrestrial ecology of the Limerick site and surrounding areas were conducted from June 1972 through March 1976 (ER-OL Section 6.1.4.3). The staff has evaluated these studies and believes they provide information that describes the terrestrial resources of the area.

The staff routinely requires quality assurance-type programs for transmission line erosion control and maintenance activities as well as low level aerial infrared photographs to identify impacts of cooling tower salt drift. The staff will determine the need for these types of programs in its preparation of the environmental protection plan which will be included as an Appendix to the license.

5.14.2 Aquatic Monitoring

The certifications and permits required under the Clean Water Act provide mechanisms for protecting water quality and, indirectly, aquatic biota. Operational monitoring of effluents will be required by the NPDES permit issued by the Commonwealth of Pennsylvania. The NRC will rely on the decisions made by the commonwealth, under the authority of the Clean Water Act, for any requirements for monitoring intake losses of aquatic biota and for any requirements for intake design changes, should they be necessary.

An environmental protection plan will be included as Appendix B to each Limerick generating station operating license. This plan will include requirements for prompt reporting by the applicant of important events that potentially could result in significant environmental impacts causally related to plant operation (for example, fish kills, mortality of any species protected by the Endangered Species Act of 1973 as amended, an increase in nuisance organisms or conditions, or unanticipated or emergency discharge of waste water or chemical substances).

5.14.3 Atmospheric Monitoring

The FES-CP did not contain a description of the onsite meteorological measurements program. The primary source of meteorological measurements at Limerick is Weather Station No. 1, which includes a main tower (Tower No. 1) extending 85.7 m above grade, which is about 915 m northwest of the reactor buildings and about 610 m north-northwest of the natural draft cooling tower for Unit 1. Weather Station No. 1 has been in operation since December 1971. The following meteorological measurements were made on this tower during the preoperational monitoring program: wind speed and direction at the 9.1-m, 53-m, and 82-m levels; horizontal and vertical wind fluctuations at the 46-m level; vertical temperature gradients between the 52.2-m and 7.9-m levels and between the 81.1-m and 7.9-m levels; and dry bulb temperatures at the 1.5-m and 7.9-m levels. Relative humidity and precipitation were measured at an elevation of 1.5 m above grade near the tower.

Two other towers have been used to provide additional information about airflow characteristics at the Limerick site. A 95.7-m tower, located across the Schuylkill River from Tower No. 1, provided additional information on temperature profiles in the river valley. A satellite tower, located south of the reactor buildings, provided additional information on low level airflow patterns.

Although the applicant claims that the entire onsite meteorological measurements system complies with the accuracy specifications presented in RG 1.23, the NRC staff identified a concern about the starting threshold of the anemometers and the characterization of the distribution of low wind speeds. The anemometers of concern installed on Tower No. 1 have starting speeds of 0.8 m/sec, compared with the starting speed of 0.45 m/sec recommended in RG 1.23. Almost 18% of the time wind speeds at Limerick are below 0.8 m/sec, and, therefore, classified as calm. Because the actual wind speed and direction for calm conditions are unknown, wind speed and direction must be inferred for use in assessments of atmospheric dispersion characteristics. Because the anemometers of concern are not capable of indicating airflow conditions a large percentage of the time, the NRC staff took the position that a more sensitive anemometer should be installed at the 9.1-m level of Tower No. 1 for use during plant operation. The applicant placed this more sensitive anemometer in service on October 15, 1983.

The meteorological measurements program during plant operation is planned to include Tower No. 1, a backup tower located about 120 m away, and the satellite tower. The applicant proposed that existing measurements and instrumentation continue during the operational program, with the exception of a change to the anemometer at the 9.1-m level of Tower No. 1 and a change from a measurement of relative humidity to a measure of dew point temperature. The proximity of the cooling towers to Tower No. 1 could cause some distortion to airflow and could affect measurements of wind speed and direction when the wind is blowing from the cooling towers toward Tower No. 1 (winds from the southeast and south-southeast). The turbulent wake of the cooling towers will probably not extend far enough to affect meteorological measurements during low wind speed (i.e., less than 2 m/sec) conditions. Meteorological measurements at Tower No. 1 will probably be affected by the cooling towers less than 10% of the time. Measured wind speeds could be reduced somewhat, and measured wind direction could be more variable. Use of a stability indicator dependent on wind direction fluctuations could indicate more unstable conditions than would otherwise be estimated. However, the staff believes that the frequency of possible cooling tower wake effects is sufficiently small, and that the potential for significant distortions of wind speed and direction measurements is also small. Therefore, the staff concludes that the location of Tower No. 1 is satisfactory for use during the routine plant operation.

5.14.4 Noise Monitoring

5.14.4.1 Point Pleasant Pumphouse

A recent ASLB ruling as setforth in Appendix G requires that the applicant conduct a field study after the transformers are placed in operation at Point Pleasant. If audible tones are found at the site boundary, the applicant will have to implement noise reduction measures (e.g. installation of barriers around the transformers). The applicant has committed to construct these physical barriers, if necessary (Boyer, 1983). The noise shall be reduced to a level so that the transformer core tones will be inaudible at the site boundary. Based on onsite measurements, the ΔL_{ex} for each tone will be determined. If those values are greater than zero, mitigative measures will have to be undertaken.

The measurement program required in the ASLB ruling involves determining, for each transformer tone, the number of dB (if any) above the threshold of audibility defined by the masking level for that tone. The steps to be carried out are

(1) Measure the broadband (nontonal) ambient nighttime (midnight to 4 a.m.) levels in all octave bands of frequency when the transformers are not

energized (step A in the ASLB ruling). From these, tone-masking sound levels (thresholds of audibility) at each tone frequency are calculated.

(2) Measure the level of the tones that exist when the transformers are energized (step B) in the one-third-octave bands that contain them for comparison with the calculated masking levels from step A, to determine audibility.

If, for any reason, it is not practicable to de-energize the transformers at any time during the prescribed measurement time period (midnight to 4 a.m.), alternative measurements will be required. In that event, only one measurement of the entire spectrum need be made, but it must be done entirely in one-third-octave bands. Any measured octave band sound level that includes a tone or tones cannot be used to determine the true background ambient sound level for that octave band. In such case, the background ambient level in any one-third-octave band containing a tone can be approximated by interpolating between those adjacent one-third-octave band levels that do not contain any tones.

If audible tones are found at the site boundary, mitigative measures might involve the use of a three-sided barrier or a full enclosure. The NRC staff is satisfied that the ASLB requirement will determine (1) if audible tones are present at the site boundary due to the transformers, and (2) that adequate mitigative measures are available and can be taken if audible tones are present. As part of the licensing process, the NRC staff will determine that the ASLB requirement is complied with on an acceptable schedule.

5.14.4.2 Bradshaw Reservoir

The staff predictions in Section 5.12.2 indicate that transformer core tones may be audible at the nearest residences B, D, and F. These predictions are not necessarily conservative. As a result, the operational measurement program to be applied to the Point Pleasant Pumping Station would be appropriate for the Bradshaw environment as well. In addition, to characterize the potential for complaints that are likely to appear if the transformer tones exceed the masking levels at the tonal frequencies by greater than 5 dB, the noise measurements proposed for the Point Pleasant site should be made at the Bradshaw pumphouse site boundary during operation, on the line between the transformers and residences B, D, and F, to determine if the tones would be audible at those points. Measures to render these tones inaudible at these points should then be applied as necessary. The applicant has committed to perform the recommended noise monitoring program (Boyer, 1983).

The measurement program recommended for Bradshaw to test for audible tones from the transformers should also be extended to include audible tones in the 1000-Hz octave band at the southeast site boundary in the direction of residence B. All doubt would be eliminated if the pumphouse roof could be upgraded to an acoustical roof deck designed to have high acoustical transmission loss. The present roof is made of corrugated sheet steel overlayed with a 3.8-cm (1½-in.) layer of perlite concrete with crushed stone. Presently a 30-dB transmission loss is assumed for the roof in the 1000-Hz octave band. If that loss could be increased to 40 dB or better, an additional 10-dB loss would result, leading to inaudible tones in the 1000-Hz frequency band at residence B. The 40-dB loss includes some tolerance as well. Increasing the 3.8-cm (1½-in.) to 7.6-cm (3-in.) thickness should provide the increased transmission loss, resulting in no audible tones at residence B. Choice of an acoustical roof deck with STC-40 or better should be satisfactory as well, with a good margin of tolerance.

5.14.4.3 Limerick Site

The NRC staff predictions in Section 5.12.3 indicate that transformer core tones may be audible at residences A and B north of the site. The predictions contain uncertainties that preclude definitive conclusions on these tones and their audibility. The operational measurement program to be applied to the Point Pleasant pumping station and Bradshaw Reservoir area would be appropriate for the area immediately beyond the northern site boundary of the Limerick site as well. If audible tones are found to be present at the northern site boundary during station operation, mitigative measures should be taken, as required for the Point Pleasant facility, to cause those tones to be inaudible.

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6 EVALUATION OF THE PROPOSED ACTION

6.1 Unavoidable Adverse Impacts

The staff has reassessed the physical, social, biological and economic impacts that can be attributed to the operation of the Limerick generating station. These impacts are summarized in Table 6.1.

The applicant is required to adhere to the following conditions for the protection of the environment:

(1) Before engaging in any additional construction or operational activities that may result in any significant adverse environmental impact that was not evaluated or that is significantly greater than that evaluated in this statement, the applicant will provide written notification of such activities to the Director of the Office of Nuclear Reactor Regulation and will receive written approval from that office before proceeding with such activities.

(2) The applicant will carry out the environmental monitoring programs outlined in Section 5 of this statement, as modified and approved by the staff and implemented in the Environmental Protection Plan and Technical Specifications that will be incorporated in the operating licenses.

(3) If an adverse environmental effect or evidence of irreversible environmental damage is detected during the operating life of the plant, the applicant will provide the staff with an analysis of the problem and a proposed course of action to alleviate it.

6.2 Irreversible and Irretrievable Commitments of Resources

There has been no change in the staff's assessment of this impact since the earlier review except that the continuing escalation of costs has increased the dollar values of the materials used for constructing and fueling the plant.

6.3 Relationship Between Short-Term Use and Long-Term Productivity

There have been no significant changes in the staff's evaluation for the Limerick generating station since the construction permit stage environmental review.

6.4 Benefit-Cost Summary

6.4.1 Summary

Sections below describe the economic, environmental and socioeconomic benefits and costs that are associated with the operation of the Limerick generating station. They are summarized in Table 6.1.

Table 6.1 Benefit-cost summary for Limerick

Primary impact and effect on population or resources	Quantity (Section)*	Impacts**
BENEFITS		
Direct		
Electrical energy	10 billion kWh/yr	Large
Additional generating capacity	2110 MWe (design rating) (Sec. 6.4.1)	Large
COSTS		
Environmental		
Damages suffered by other water users		
Surface water consumption	(Sec. 5.3.2)	Small
Surface water contamination	(Sec. 5.3.2)	Small
Groundwater consumption	(Sec. 4.3.2)	None
Groundwater contamination	(Sec. 4.3.2)	None
Damage to aquatic resources		
Impingement and entrainment	(Sec. 5.5.2)	Small
Thermal effects	(Secs. 5.3.2 & 5.5.2)	Small
Chemical discharges	(Sec. 5.3.2)	Small
Diversion flow effects (East Branch)	(Sec. 5.5.2.3)	Moderate
Damage to terrestrial resources		
Station operations	(Sec. 5.5)	Small
Transmission line maintenance	(Sec. 5.5.1)	Small
Adverse socioeconomic effects		
Loss of historic or archeological resources	(Sec. 5.7)	Moderate
Increased demands on public facilities and services	(Sec. 5.8)	Small
Increased demands on private facilities and services	(Sec. 5.8)	Small
Noise	(Sec. 5.12)	Moderate-Small
Adverse nonradiological health effects		
Water quality changes	(Sec. 5.3.2)	None
Air quality changes	(Sec. 5.4)	

*See footnotes at end of table.

Table 6.1 (Continued)

Primary impact and effect on population or resources	Quantity (Section)*	Impacts**
Adverse radiological health effects		
Routine operation	(Sec. 5.9.3)	Small
Design basis accidents	(Sec. 5.9.4)	Small
Severe accident risks	(Sec. 5.9.4)	Small
Uranium fuel cycle	(Sec. 5.10)	Small

*Where a particular unit of measure for a benefit/cost category has not been specified in this statement or where an estimate of the magnitude of the benefit/cost under consideration has not been made, the reader is directed to the appropriate section of this report for further information.

**Subjective measure of costs and benefits is assigned by reviewers, where quantification is not possible: "Small" = impacts that in the reviewers' judgments, are of such minor nature, based on currently available information, that they do not warrant detailed investigations or considerations of mitigative actions; "Moderate" = impacts that in the reviewers' judgments are likely to be clearly evident (mitigation alternatives are usually considered for moderate impacts); "Large" = impacts that in the reviewers' judgments, represent either a severe penalty or a major benefit. Acceptance requires that large negative impacts should be more than offset by other overriding project considerations.

6.4.2 Benefits

A major benefit to be derived from the operation of the Limerick station is the approximately 10 billion kWh of baseload electrical energy that will be produced annually (this projection assumes that both units will operate at an annual average capacity factor of 55%). The addition of the plant will also improve the applicant's ability to supply system load requirements by contributing 2110 MW of generating capacity to the Philadelphia Electric Company system (1055 MW from Unit 1 in 1985 and 1055 MW from Unit 2 in 1989).

6.4.3 Costs

No significant socioeconomic costs are expected from either the operation of the Limerick generating station or from the number of station personnel and their families living in the area. The socioeconomic impacts of a severe accident could be large; however, the probability of such an accident is small.

6.5 Conclusion

As a result of its analysis and review of potential environmental, technical, and social impacts, the NRC staff has prepared an updated forecast of the effects of operation of the Limerick generating station. The NRC staff has determined that the Limerick generating station can be operated with minimal environmental impact. To date, no new information has been obtained that alters the overall favorable balancing of the benefits of station operation versus the environmental costs that resulted from evaluations made at the construction permit stage.

6.6 Reference

U.S. Nuclear Regulatory Commission, NUREG-0586, "Draft Generic Environmental Impact Statement on Decommissioning Nuclear Facilities," January 1981.

7 LIST OF CONTRIBUTORS

The following personnel of the U.S. Nuclear Regulatory Commission participated in the preparation of the Final Environmental Statement:

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B. J. Richter	Cost-Benefit Economist; M.A. (Economics) 1970; Socio-Economics, 13 years experience.
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E. H. Markee	Senior Meteorologist; M.S. (Meteorology) 1967; Meteorology, 30 years experience
S. Acharya	Senior Radiological Engineer; Ph.D. (Physics) 1971; 14 years experience.
C. R. Nichols	Senior Nuclear Engineer; Ph.D. (Chemical Engineering) 1965; Chemical/Nuclear Engineering, 25 years experience; Licensed Professional Engineer.

LIST OF CONTRIBUTORS (Continued)

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J. B. Read	Senior Physical Scientist; Ph.D. (Physics and Chemistry) 1962; 21 years experience.
M. R. Shuttleworth	Licensing Assistant; 11 years experience.
L. W. Bell	Nuclear Engineer; M.S. (Physics) 1967; 26 years experience.
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E. S. Chelliah	Nuclear Systems Engineer; M.S. (Nuclear Engineering) 1972, (Electrical Engineering) 1975; 10 years experience.
C. M. Ferrell	Site Analyst; B.S. (Physics) 1950; 27 years experience.
A. Ibrahim	Seismologist, Ph.D. (Geophysics) 1967; 15 years experience.
J. Sears	Senior Reactor Safety Engineer (Mechanical Engineer); 24 years experience
L. Reiter	Section Leader, Geosciences Branch, Ph.D. (Geophysics) 1971; 12 years experience.

8 LIST OF AGENCIES, ORGANIZATIONS, AND PERSONS TO WHOM COPIES OF THE DRAFT ENVIRONMENTAL STATEMENT WERE SENT

Advisory Council on Historic Preservation
Chairman, Board of Supervisors of Limerick Township
Delaware Valley Regional Planning Commission
Maryland Attorney General
Maryland Department of Natural Resources
Maryland Department of State Planning
New Jersey Attorney General
New Jersey Department of Public Utilities
New York Attorney General
New York Technical Development Programs Office
Pennsylvania Attorney General
Pennsylvania Department of Environmental Resources
Pennsylvania State Clearinghouse
U.S. Department of Agriculture
U.S. Department of the Army, Corps of Engineers
U.S. Department of Commerce
U.S. Department of Energy
U.S. Department of Health and Human Services
U.S. Department of Housing and Urban Development
U.S. Department of Interior
U.S. Department of Transportation
U.S. Environmental Protection Agency

9 STAFF RESPONSES TO COMMENTS ON THE DRAFT ENVIRONMENTAL STATEMENT

Pursuant to 10 CFR 51, the "Draft Environmental Statement Related to the Operation of Limerick Generating Station, Units 1 and 2" (DES) was transmitted, with a request for comments to the agencies and organizations listed in Section 8. In addition the NRC requested comments on the DES from interested persons by a notice published in the Federal Register on June 30, 1983 (48 FR 30227). A similar transmittal was made for the supplement to the DES and the request for comments on it was published in the Federal Register on December 22, 1983 (48 FR 56665).

The organizations and individuals who responded to the requests for comments are listed below. The letters are reproduced in Appendix A. In parentheses after the name of each commenter are the initials used to identify the commenter later in this section and the page number of this section on which the response begins. The commenters were as follows:

<u>DES Commenters</u>

City of Philadelphia (Phil)

Commonwealth of Pennsylvania, Department of Environmental Resources (PDER)

Delaware River Basin Commission (DRBC)

Doherty, John F. (JFD)

Limerick Ecology Action (LEA)

Lochstet, William A. (WAL)

The Philadelphia Electric Company (applicant) (PECo)

Lochstet, William A. (WAL)

The Philadelphia Electric Company (applicant) (PECo)

Sugarman and Denworth (SD)

U.S. Department of the Army, Philadelphia District, Corps of Engineers (DA/CE)

U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA)

U.S. Department of Health and Human Services, Food and Drug Administration (FDA)

U.S. Department of Housing and Urban Development, Philadelphia Regional Office, Region III (HUD)

DES Commenters (Cont'd)

U.S. Department of the Interior (DOI)

U.S. Environmental Protection Agency, Region III (EPA)

DES Supplement Commentors

U.S. Department of Agriculture, Economic Research Service (DA/ERS)

U.S. Environmental Protection Agency, Region III (EPA)

The Philadelphia Electric Company (applicant) (PECo)

Pennsylvania Intergovernmental Council (PIC)

U.S. Department of the Interior (DOI)

U.S. Department of Health and Human Services, Food and Drug Administration (FDA)

The DES comments from the Deptartment of the Army and the Department of Housing and Urban Development and DES Supplement Commenters from the Department of the Army, Food and Drug Administration, the Maryland Department of State Planning, the Department of Agriculture did not require a response because these agencies had no comments. Statements within other sets of comments that either indicated agreement with the environmental statements or were not comments on the environmental statements were not responded to. The remaining letters and statements received a staff response. The staff's consideration of these comments and its disposition of the issues involved are reflected in part by revised text in the pertinent sections of this FES and in part by the following discussions in this section.

Responses to DES Comments

Phil-1

The City believes that conclusions as to environmental impact of Unit No. 2's operation are premature and issuance of such conclusions at this time is a violation of NEPA.

The DES and this FES were prepared in accordance with the Commission's regulations as set forth in Title 10 of the Code of Federal Regulations, Part 51, which implements the National Environmental Policy Act of 1969 (NEPA). The commentor has not provided any specific reference to the regulations in 10 CFR 51 or to the DES to constitute a basis for the comment that issuance of Unit 2 environmental impact conclusions at this time is a violation of NEPA. The staff also finds no basis to conclude that issuance of the Unit 2 environmental impact conclusions at this time would preclude subsequent implementation or enforcement of legally enacted environmental requirements for Unit 2. The same would also be true for Unit 1.

PDER-1

PDER feels that the matter of low level radioactive waste storage and disposal should be addressed.

For the short term, it is expected that the health and safety of the public and the workers will be assured through the use of existing burial grounds (Beatty, NV; Barnwell, SC; and Hanford, WA) and plant-management practices of minimizing waste generation, volume reduction, and temporary onsite storage for low level wastes.

For the longer term, several actions are underway to speed the establishment of additional low-level radioactive-waste burial grounds. First, the NRC has published a new rule, 10 CFR Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste." Second, the U.S. Congress passed the Low-Level Waste Policy Act in 1980, which assigned the responsibility for low-level waste disposal to the states and included language that allows states to form regional state compacts that could exclude wastes from outside the compact after 1986. Many state and regional organizations are evaluating their disposal needs and moving toward the establishment of regional disposal sites or individual state disposal sites.

PDER-2

PDER noted that the DES did not include the severe accident analysis.

This analysis was included in Supplement 1 to the DES which was issued in December 1983.

PDER-3

PDER corrected the Blue marsh flood control storage area in 4.3.1.1.1.

The text on page 4-20 has been changed to reflect the comment.

PDER-4

PDER suggested an identifying number for the stream flow gauge in 4.3.1.1.1.

The text on page 4-20 has been changed to reflect the comment.

PDER-5

PDER suggested noting that the Schuylkill River is a component of the Pennsylvania Scenic River System.

FES Section 4.2.2 has been revised to incorporate this new information.

PDER-6

PDER comments that Section 5.2.2 should indicate that railroad/transmission line right-of-ways should contain easements permitting recreational trails and river access for the Cromby-Plymouth Meeting section.

It is a matter of public record that Philadelphia Electric Company has entered into an agreement with Chester County, Pennsylvania for an easement to establish a hiking and biking trail in three townships and one borough along its Cromby to Plymouth Meeting transmission line corridor. Section 5.2.2 has been revised to indicate the existance of easements for recreational trails along the PECO transmission line rights-of-way.

DRBC-1

DRBC offers clarifying information on the Schuylkill River discharge mixing zone with respect to chlorine and thermal dissipation.

The text of Section 5.3.2.3 has been revised to remove the references to the thermal mixing zone, as applicable to other discharge constituents. The text indicates that a designated mixing area may be defined for these constituents, on a case specific basis for LGS.

JFD-1

JFD asserts that the DES is deficient because it does not contain the severe accident analysis.

The staff agrees with the comment on the need for this and, as stated in several places in the DES, planned to publish that analysis in a Supplement to the DES. The Supplement to the DES, published in December 1983, included the severe accident assessment. Comments received on the DES Supplement are also included and responded to in this FES.

JFD-2

The commentor has correctly interpreted that paragraph 2 on page C-6 of the Limerick DES does not refer to the potential health effects resulting from the operation of nuclear reactors.

This paragraph refers to the population dose commitments due to the release of radon-222 from stabilized-tailings piles at uranium mills for each year of operation of the model 1000-MWe Light Water Reactor (LWR). The staff has revised Appendix C of the DES to incorporate this comment and to clarify this issue in the FES. The NRC staff has also considered the non-fatal cancers and birth defects in this updated assessment of the potential radiological impacts of the supporting fuel cycle for each year of operation of the model 1000-MWe LWR.

The staff considered and discussed the number of potential non-fatal cancers, as well as genetic effects in paragraphs 8, 9 and 10 of Section 5.9.3.1.1 of the DES. The last sentence of paragraph 8 also had given the range of the total number of potential non-fatal cancers relative to the number of potential fatal cancers as follows:

> "The number of potential non-fatal cancers would be approximately 1.5 to 2 times the number of potential fatal cancers, according to the 1980

report of the National Academy of Science's Advisory Committee in the Biological Effects of Ionizing Radiation (BEIR III, 1980).*"

The potential radiological impacts of the supporting fuel cycle are summarized in Table C-5 of Appendix C of the Limerick FES for an environmental dose commitment time of 100 years. From the risk analysis in Appendix C, the staff concludes that, in spite of the extreme conservatism involved in the source terms assumed for tritium, carbon-14, krypton-85 and iodine-129, both the dose commitments and health effects of the LWR-supporting uranium fuel cycle are very small when compared with dose commitments and potential health effects to the U.S. population resulting from all natural-background sources.

<u>JFD-3</u>

JFD comments that the effect of the transmission lines on migratory birds has evidently not been explored or considered.

Contrary to the comment, the effect of the transmission lines on birds was explored and considered as indicated in Section 5.5.1.2. Since publication of the DES the NRC staff has discussed bird impaction events at transmission lines with state and local wild life biologists. Based on their assessment, in conjunction with the staff's assessment of conditions at the existing transmission lines in the region, the staff concludes that the monitoring programs previously described in the DES are no longer necessary. Sections 5.5.1 and 5.14.1 have been revised to reflect the more recent information.

<u>JFD-4</u>

The comment states that the staff calculations discussed in Appendix D should indicate whether contamination of women at menstruation when breast tissue cells are in rapid multiplication is accounted for.

It seems that the commenter may be confused about the increased breast size of women at menstruation due to the accumulation of body fluids with the actual rapid multiplication of breast tissue cells during puberty or pregnancy. The staff interpreted this comment as being basically concerned with the increased sensitivity of the female breast tissues to radiation-induced cancers if irradiation occurs when breast tissue cells are multiplying rapidly.

The staff is aware of the evidence from human studies which suggest that female breast tissue may be more sensitive to radiation carcinogenesis if irradiation occurs at times of breast tissue proliferation (1, 2). As stated in the DES, the staff has concluded that the risks to the general public from exposure to radioactive effluents and transportation of fuel and wastes from the annual operation of the Limerick facility are very small fractions of the estimated normal incidence of cancer fatalities and genetic abnormalities due to causes unrelated to the operation of the Limerick facility in the year 2000 population.

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*Advisory Committee on the Biological Effects of Ionizing Radiations, BEIR III, "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation," National Academy of Sciences/National Research Council, July 1980.

On the basis of the preceding comparison, the NRC staff concludes that the risk to the public health and safety from exposure to radioactivity associated with the normal operation of the Limerick facility will be very small.

1. J. D. Boice, Jr., and B. J. Stone. Interaction between radiation and other breast cancer risk factors, pp. 231-249. In Late Biological Effects of Ionizing Radiation. Vol. 1. Vienna: International Atomic Energy Agency, 1978.

2. D. H. McGregor; C. E. Land, K. Choi, et al. Breast cancer incidence among atomic bomb survivors, Hiroshima and Nagasaki, 1950-69. J. Natl. Cancer Inst. 59:799-811, 1977.

<u>LEA-1</u>

LEA noted that the DES stated that the action called for is issuance of operating licenses for Limerick Generating Station Units 1 and 2.

As noted in the DES Summary and Conclusions paragraph (8), the staff's conclusions in the DES were with respect to the analysis and evaluation set forth in the DES. The regulations in 10 CFR Part 51 require that an environmental impact statement be prepared and circulated prior to issuance of an operating license. The staff recognized and stated in the DES that the DES did not include the analysis of severe accidents. Therefore, the staff recognized that those findings were required to be prepared and circulated prior to reaching a final conclusion on the issuance of the LGS operating licenses. This was done by the issuance of Supplement 1 to the DES. This FES including its Summary and Conclusions, beginning on page v, addresses the scope of issues covered by both the DES and Supplement 1 to the DES.

<u>LEA-2</u>

LEA comments that the only discussion of emergency planning is ludicrous.

This comment provides a minimum of specificity; however the staff notes that the discussion of emergency planning assesses the impact on the environment; it is not a detailed analysis of the adequacy of the station's emergency preparedness plans. Also as stated in Section 5.9.4.4(3) of DES supplement and this FES, no operating license will be issued to the applicant unless a finding is made by the NRC that the state of onsite and offsite emergency preparedness provides reasonable assurance that adequate protective measures can and will be taken in the event of a radiological emergency. The preparation and reporting of the staff's findings on emergency preparedness are discussed in Section 5.9.4.4(3) of this FES.

<u>LEA-3</u>

LEA comments that most of the DES attempts to justify continued construction and operation of the Point Pleasant water diversion plan for use at Limerick.

The staff does not agree that the DES attempts to justify the Point Pleasant water diversion plan. As stated in paragraph (5) of the Summary and Conclusions and in the Abstract of the DES and this FES, the statements assess various impacts associated with operation of the facility and balances these impacts against anticipated annual energy production benefits pursuant to NEPA and 10 CFR Part 51.

LEA-4

LEA questioned whether the NRC intends to objectively review the revised contentions, testimony and litigation yet to be filed in this proceeding by intervenors in this case.

The staff's participation in the Limerick licensing process will be in accordance with Federal Regulations and regulatory requirements as applicable to the various aspects of the case.

WAL-1

Dr. Lochstet contends: "The NRC estimate [of potential health impact from radon-222 releases from the uranium fuel cycle] is...more than 100,000 times too low as compared to the sum of 600,000 deaths [which Dr. Lochstet has estimated]." The basis for Dr. Lochstet's contention is that the NRC staff has arbitrarily evaluated the health impacts of radon-222 releases from the wastes generated in the fuel cycle for 1000 years or less, rather than for a time period long enough to allow the extremely long-lived members of the uranium-238 series to decay to radon-222. Dr. Lochstet estimates that radon-222 emissions from the wastes from each annual reactor fuel requirement will cause about 600,000 deaths over a period of more than 1 billion years.

The major difference between the staff's estimated health effects from radon-222 emissions and Dr. Lochstet's extimated values is the issue of the time period over which dose commitments and health effects from long-lived radioactive effluents should be evaluated. Dr. Lochstet has integrated dose commitments and health effects over what amounts to an infinite time interval, whereas the staff has integrated dose commitments from radon-222 releases over a 100-year period, a 500-year period, and a 1000-year period.

The staff has not estimated health effects from radon-222 emissions beyond 1000 years for the following reason. Predictions over time periods longer than even 100 years are subject to great uncertainties. These uncertainties result from, but are not limited to, political and social considerations, population size, health characteristics, and, for time periods on the order of thousands of years, geologic and climatologic effects. In contrast to Dr. Lochstet's conclusion, some authors estimate that the long-term (thousands of years) impacts from the uranium used in reactors will be less than the long-term impacts from an equivalent amount of uranium left undisturbed in the ground (Cohen, 1979).

Consequently, the staff has limited its period of consideration to 1000 years or less for decision-making and impact-calculation purposes.

Cohen, B.L., "Radon: Characteristics, Natural Occurrence, Technological Enhancement, and Health Effects," Vol 4, Progress in Nuclear Energy, 1979.

PECO-1

PECO suggests including the Delaware River in the sentence on page v.

The text on page v has been corrected to reflect the comment.

PECO-2

PECO refers the staff to responses on noise monitoring.

The conclusion statements in paragraph 4(u) have been changed to reflect the commitments of the applicant with respect to noise monitoring in the vicinity of the Bradshaw Reservoir, physical barrier construction for sound attenuation (if necessary) at the Point Pleasant pumphouse and ventilation louvre modification at the Bradshaw Reservoir pumphouse. See responses to PECO comments #18, 20, and 21.

PECO-3

PECO suggested revising Section 1 to reflect multiple turbine generators and heat dissipation systems for the 2 unit plant.

The text has been revised to reflect the comment.

PECO-4

PECO believes that two of the Table 4.1 values are in error.

The minimum and average Delaware River/Perkiomen Creek makeup flowrates for the June through October time period have been changed in Table 4.1 as suggested in the comment. The values shown are based on application of a conversion factor of 1.54723 ft^3/sec per million gallons/day to the values shown in ER-OL Table 3.3-1.

PECO-5

PECO suggests changes to 4.2.4 to reflect Schuylkill River water withdrawal conditions imposed by the DRBC.

Section 4.2.4 has been revised to reflect the use of Schuylkill River water under temperature and flow conditions imposed by the DRBC.

PECO-6

PECO notes that there are no automatic means to activate the Perkiomen Creek intake screens.

Section 4.2.4 has been revised to state that the Perkiomen Creek intake screens will be cleaned by a manually activated system.

PECO-7

PECO suggested a lower range for the cooling water system concentration factor.

The concentration factor given in the DES for the June through October time period was based on the ratio of the makeup to blowdown flowrates given in Table 4.1. The average makeup flowrate for this time period has been revised (see response to PECO #4). Based on the revised value and the average monthly blowdown values expected for the time period, the average concentration factor is calculated to be about 3.2. Section 4.2.6.2 has been changed to indicate this revised value.

PECO-8

PECO suggested updating Section 4.2.7 to be consistent with a later revision to the ER-OL.

The text of FES Section 4.2.7 has been revised to be consistent with the information contained in ER-OL Revision 14, submitted in July, 1983.

PECO-9

PECO notes that the source of the Table 4.13 data is the NRC staff.

The comment is correct and the footnote to Table 4.13 has been changed.

PECO-10

PECO corrects the reference to ER-OL Table 2.1-19 on page 4-54.

The comment is correct and the change has been made.

PECO-11

PECO suggests an editorial change to page 5-9.

The appropriate change has been made to the text of Section 5.3.2.3.

PECO-12

PECO suggested changes in Section 5.3.3.2 based on their understanding of the ASLB March 8, 1983 Partial Initial Decision.

The section as written, accurately reflects the staff's conclusions regarding velocities past the wedgwire screens for flows of 3000 and 2500 cfs. Although the ASLB in its Partial Initial Decision did not specifically state the minimum values as determined by the staff, the ASLB did cite Del-Aware's disagreement with the distances into the river at which the applicant indicated the velocity measurements were made. The stated minimum velocities (.77 fps and .64 fps) for river flows of 3000 and 2500 cfs, respectively, were determined by the staff assuming the worst conceivable error in distance measurement on the part of the applicant. This resulted in a reduction of 25% of the velocities calculated by assuming that the applicant's measurements were correct. The staff is in agreement with the ASLB in asserting that 1.0 and 0.8 fps are the best estimates of velocity past the screens for river flows of 3000 and 2500 cfs, respectively. The minimum velocities presented, however, are considered to be pertinent to the ASLB's Partial Initial Decision as well as staff conclusions regarding the plant's environmental impact and should remain part of the statement.

PECO also offered a correction to the size of the Bradshaw Reservoir-Perkiomen Creek pipeline.

The text on page 5-18 has been changed to reflect the comment.

PECO-13

The staff agrees with the comment that the word "not" should be inserted between the words "will and adversely" in the first line, fourth paragraph, page 5-25. The FES text has been revised to reflect this change.

PECO-14

PECO notes that it is not the constructor, owner or operator of the Point Pleasant pipeline.

The text of FES Sections 5.5.1.4 and 5.14.1 have been revised to indicate the correct owner and operator of the combined transmission main and the impact assessments and controls regarding erosion of the pipeline corridor.

PECO-15

PECO comments that two of the compound escalation rates in Section 5.8 are inconsistent. Subsequently PECO, in a letter from John S. Kemper, PECO, to A. Schwencer, NRC, dated December 30, 1983, provided revised data for payroll and Public Utility Realty Tax figures.

Section 5.8 has been changed to reflect this information.

PECO-16, 17

Comments Nos. 16 and 17 on Tables 5.8 and 5.9, respectively, are editorial in nature and identify typographical errors.

These errors have been corrected in Tables 5.8 and 5.9 of the FES Final Environmental Statement (FES).

PECO-18

PECO comments that the Bradshaw Reservoir design engineer has been directed to implement the ventilating louvre modification.

The text of Section 5.12.2.1 has been changed to reflect the modification of the Bradshaw Reservoir pumphouse ventilation louvre systems by installing vertical duct attenuators.

PECO-19

PECO comments that residences C and D on Figure 5.8 are inaccurately shown.

Figure 5.8 has been changed to indicate that the locations of residences C and D are across the Schuylkill River from the LGS site, off the figure.

PECO-20

PECO responds to DES 5.14.4.1 by committing to install Point Pleasant pumphouse noise barriers if necessary.

The text of Section 5.14.4.1 has been changed to indicate the applicant's commitment to modify the Point Pleasant pumphouse by installing barriers around the pumphouse transformers, if found necessary by the operational noise survey.

PECO-21

PECO responds to DES 5.14.4.2 by noting that the Bradshaw Reservoir design engineer has been directed to implement the noise monitoring program.

The text of Section 5.14.4.2 has been changed to reflect conduct of a noise monitoring program in the vicinity of the Bradshaw Reservoir during its initial period of operation.

PECO-22

PECO comments that the operating savings attributable to Limerick in Section 6 of the DES are too low.

This matter was also addressed by PECO in its comments on the DES Supplement. Refer to the response to PECO 32 in the second part of this section.

PECO-23

PECO comments that Table 6.1 indicates that the effect on historic and archeological resources of Limerick is moderate which appears to be inconsistent with the discussion in Section 5.7. PECO believes that the classification should be 'small' or 'none'. Additionally, to update the discussion in Section 5.7, it should be noted, regarding work by the NWRA at their Point Pleasant pumping station, the Corps of Engineers did include in their permit a condition that work shall be performed in accordance with the "Memorandum of Agreement." Construction work started in January 1983 and as required an archeologist is on site.

The footnotes to Table 6.1 describe the impacts as being "Subjective measure of costs and benefits...assigned by reviewers." The footnotes also note that moderate impacts are those"...that in the reviewers judgments are likely to be clearly evident (mitigation alternatives are usually considered for moderate impacts)." Because of the mitigative efforts involved in the potential archeologic and historic resource impacts, no inconsistency exists according to the Table's definitions and the staff's measurement.

With regard to the discussion of the Point Pleasant pumping station, as discussed in Section 5.7, the staff notes the additional information this comment provides and has made a slight change in the Historic and Archeologic Impact section.

PECO-24

PECO suggests that Appendix D should have some statement which makes it clear that the doses calculated for the hypothetical individual member of the public (that is, the maximally exposed individual) are conservative.

The staff notes that the last sentence of paragraph one, Section 2(a) of APPENDIX D on page D-2 of the DES states that: "This method tends to overestimate the doses because assumptions are made that would be difficult for a real individual to fulfill." This statement is consistent with and supported by the following statement in paragraph 4 on page 5-39 of the Limerick DES:

> "These doses, calculated for the "maximally exposed" individual (that is, the hypothetical individual potentially subject to maximum exposure), form the basis of the NRC staff's evaluation of impacts. Actually, these estimates are for a fictitious person because assumptions are made that tend to overestimate the dose that would accrue to members of the public outside the plant boundaries. For example, if this "maximally exposed" individual were to receive the total body dose calculated at the plant boundary as a result of external exposure to the gaseous plume, he/she is assumed to be physically exposed to gamma radiation at that boundary for 70% of the year, an unlikely occurrence."

However, it should be noted that the staff's dose estimates do reflect use of available site-specific values for various parameters involved in each dose pathway. These include calculated or observed values for the amounts of radionuclides released in the gaseous and liquid effluents, meteorological information (for example, wind speed and direction) specific to the site topography and effluent release points, and hydrological information pertaining to dilution of the liquid effluents as they are discharged.

Even though the staff's dose estimate for gaseous effluents represents higher dose estimates than actually expected for a member of the public for each applicable foodchain pathway, the estimate considers, for example, where people live, where vegetable gardens are located, and where cows are pastured.

PECO also commented that, "The most conservative aspect of the assessment is the assumption that all releases in those sectors downwind of the natural draft cooling towers should be treated as ground level releases...."

The staff's objective is that assessments of consequences of routine releases be made on a realistic basis such that it is unlikely that the true radiological impact is substantially underestimated. Diffusion experiments performed at the Rancho Seco site domonstrated that cooling towers mix effluents in their wakes rapidly down to the ground under some unspecified atmospheric stability conditions. In making an assessment of the consequences of routine radiological releases into the wake of the cooling towers, the staff conservatively assumed a ground release for these wake-affected wind directions to eliminate the possibility of substantially underestimating radiological impact. Less conservative assumptions could be made if a complete study is made by the applicant of all building and structure wake effects at the site related to meteorological measurements.

<u>SD-1, 5</u>

SD makes several broad comments on the DES assessment of the supplementary cooling water system focussing on the participation of the NRC, the DRBC and the PaDER.

The NRC statement to the DRBC regarding the environmental review for the Limerick Generating Station operating license application clearly indicated that this review would consider new information available since the publication of the

FES-CP in November 1973. The NRC assessment would consider the impacts associated with the operation of the LGS, including those necessary to support its operation (e.g., the Delaware River Point Pleasure pumping facility). The assessments in Section 5 of the DES clearly include those with the potential to adversely affect the Delaware River. In accordance with the procedural provisions of the Council on Environmental Quality to avoid unnecessary duplication of effort and to make use of existing applicable environmental impact assessments the NRC considered the assessments, approvals and permits of the DRBC, the PaDER, and the Corps of Engineers.

The references used in DES Sections 4 and 5 clearly show that the staff used a wide range of sources of information in assessing the impacts of operation of LGS. Contrary to the allegation of the comment, the staff did not rely exclusively on the materials and data of the DRBC and PaDER.

The Commission position with respect to consideration of alternatives in operating license proceedings is given in FES Section 3.

SD-2

SD makes a broad comment that the DES ignores a Pennsylvania PUC decision and instead claims socio-economic benefits from construction of Limerick.

The staff notes that construction issues were analyzed in the FES-CP, November 1973 and the construction permits were issued in 1974. This FES analyzes the operating impacts of Limerick in accordance with 10 CFR Part 51 which implements NEPA. The comment does not provide any specific reference to the regulations in 10 CFR Part 51 or to the DES to constitute a basis for the comment.

SD-3

SD comments that the DES fails to deal with loss of a spawning area for American shad.

Sections 5.5.2.2 and 5.5.2.5 of this environmental statement consider the impacts of water withdrawal at Point Pleasant to the aquatic resources of the Delaware River. Also, it summarizes findings by the Delaware River Basin Commission, the AEC and the NRC. Impacts to American shad and shortnose sturgeon were considered by the NRC in the Partial Initial Decision on Supplementary Cooling System Contentions issued by the ASLB on March 8, 1983. This decision is included as Appendix G and the pertinent findings are summarized in Sections 5.5.2.2 and 5.6.2 of this environmental statement.

SD-4

SD comments that the DES fails to acknowledge the harm caused to the Delaware Canal.

This comment fails to identify the particular harm alleged to be caused to the canal hence no response can be made. Nevertheless, it should be noted that Section 5.7 of the EIS includes a discussion of a Memorandum of Agreement between the legally responsible parties concerning the avoidance, minimization, and mitigation of the possible pumping station impacts on properties listed or eligible for listing in the National Register of Historic Places. The staff also wishes to note that the NRC is not a signatory of that Memorandum.

Lastly, the comment concerning no reference to the Landmark in the EIS is incorrect, as the canal is mentioned in Section 4.3.7.

NOAA-1

NOAA addresses the need for them to be notified in the event geodetic control survey monuments need to be relocated.

Any such notification requirements would be the direct responsibility of the Applicant or the organizations involved with the need to relocate the monuments.

FDA-1

The assessment of the environmental consequences of severe accidents were, as the commentor observed, published in Supplement 1 to the DES. FDA submitted a letter on the DES Supplement as noted elsewhere in this section.

FDA - 2

FDA suggested that an indication of the capabilities of the radiological monitoring program to measure releases in the unlikely event of an accident be provided.

The following offsite radiation monitoring capabilities are available to the applicant during emergency conditions:

1. PECO - environmental monitoring program consisting of offsite sample locations at which real time surveys can be made.
2. PECO contractor - KANBERRA - Radiation Management Corporation utilizing their environmental monitoring van equipped for field isotopic analysis of samples.
3. United States Department of Energy (DOE), Brookhaven National Laboratory (BNL) monitoring team.
4. Bureau of Radiation Protection, Pennsylvania Department of Environmental Resources (available within two hours).

These capabilities include the monitoring of radioiodines in the presence of radionoble gases.

Department of Interior

NOTE: Attached to the FES as Appendix O is a letter from Mr. Gerald Hansler containing DRBC staff responses to comments from U.S. Department of the Interior on the DES on Limerick Generating Station. Because the DRBC has authority to allocate water resources in the Delaware River Basin, the NRC staff responses to comments on water allocation will reference this letter.

DOI-1

DOI addresses the capability to maintain flowrates in the Delaware River during drought periods.

During the moderate drought period specified in the comment (1980-81), the DRBC has reduced the flow objective at Trenton from 3000 cfs to 2500 cfs to conserve storage. This decision was made prior to the present reservoir operating rules which were adopted in June 1983. Under the present rules, flow objectives will be modified in accordance with the level of combined storage in New York City's Delaware Basin Reservoirs. In its review of the 1980-81 drought period, the NRC staff determined the greatest deficiency in flows below 3000 cfs as occurring during the period December 17, 1980 to February 1, 1981. This deficiency was calculated to be about 18,500 cfs-days which is less then the conservation storage in the Beltsville Reservoir. Hence, Beltsville Reservoir alone could have maintained flows at Trenton significantly above 2500 cfs during this period under the present operating rules. DRBC reservoir operations and water allocations are discussed in detail beginning on page 1 of Mr. Hansler's letter (Appendix O).

DOI-2

DOI addresses the requirements for minimum flows in the Perkiomen Creek Basin.

The applicant will be required to maintain flows of 27 cfs in the East Branch of Perkiomen Creek throughout the normal low flow period, beginning with the day each year that water is pumped from Bradshaw Reservoir to the East Branch and ending when pumping is no longer required for operation of the Limerick plant. During average streamflow conditions this period will extend from mid-April to mid-November. For the remainder of the year, a minimum flow of 10 cfs must be maintained in the East Branch. The pumping rate from Bradshaw Reservoir will vary according to the natural flow in East Branch at the time of pumping. The text has been modified to clarify these points. See also page 7, 19 and 20 of Mr. Hansler's letter (Appendix O).

DOI-3

DOI addresses the adequacy of the water loss rate between the Delaware River to Limerick.

Increased evaporation losses from a stream induced by increased flows will be roughly proportional to the increase in surface area of the stream. The staff determined from the applicant's hydraulic survey of East Branch Perkiomen Creek that the increase in surface area caused by average pumpage plus median flow in the stream over median flow alone will be approximately 110,000 ft^2 over the 22 mile length of the stream. The surface area of Bradshaw Reservoir will add approximately another 80,000 ft^2 for evaporation. The average shallow lake evaporation for the region is 24 inches for the period May through October. Without considering rainfall (which will decrease net loss) the average evaporation loss due to the Perkiomen Creek diversion is about 0.1 cfs.

Groundwater infiltration may be treated in a similar manner, that is, the increased loss due to infiltration will be proportional to the increase in wetted perimeter of the stream which is approximately equal to the increase in surface area (110,000 ft^2) due to the increased flow. Because the stream is perennial it is reasonable to assume that most of the channel length is effluent (groundwater contributes to stream flow). However even assuming one half the length to be influent, the permeability of the streambed to be about 10^{-3} cm/sec, and the gradient to be one, results in an increased infiltration of about

1.8 cfs. In regard to infiltration from the pipeline, the DRBC will require the applicant to monitor for leaks and repair any found.

Hence, the staff concludes that the water losses due to evaporation and infiltration will be considerably less than the applicant's contingency allowance of 6.5 cfs.

Channel storage is the only significant mechanism for water loss in the East Branch. This will be minimized, however, during low flow periods when steady pumping is maintained. See also page 7 of Mr. Hansler's letter (Appendix O of the FES).

DOI-4

DOI suggested revisions to reflect more recent information on the use of the Point Pleasant area for spawning by alosids.

As a result of this comment, the NRC staff contacted the U.S. Fish and Wildlife Service (FWS) regarding the 1982 ichthyoplankton studies at Point Pleasant. FWS provided to the staff 22 pages of raw tabular data resulting from its ichthyoplankton study during the period April 16-July 21, 1982.[3] Those data are summarized here in Tables 9.1 and 9.2, with respect to species composition and the occurrence of American shad and other clupeids during that time period. At least 18 species were collected. FES Section 4.3.4.2.1 has been revised to reflect these data.

DOI-5

DOI suggested that Table 4.1 and the text be revised to state the range of Limerick plant consumptive water loss and to indicate the potential for year round pumping from the Delaware River.

The volumetric flowrate figure given for the Point Pleasant intake on p. 4-10 of the DES (71 ft^3/sec or 46 mgd) represents the maximum design physical capability of the intake. This capacity includes an approximate 10% allowance for seepage/evaporation loss in transit to the LGS, thereby providing the capability to supply the applicant's estimated maximum water need for consumptive make-up for both units at full power under the most extreme environmental conditions when water from the Schuylkill River is unavailable. This water need is estimated to be about 65 ft^3/sec or 42 mgd as shown on DES p. 4-12 (not p. 4-10 as indicated in the comment) (see ER-OL Table 3.3-1 and response to staff question E291.4). The sizing of the diversion and specification of the in transit water loss is given on DES p. 4-24. The incorrect section reference on P. 4-10 has been changed to indicate Section 4.3.1.3.

The water use values shown in DES Table 4.1 represent the estimated overall average and range of monthly average values. The overall average withdrawal rate is shown in the table to be 55.7 ft^3/sec during the time period when the diversion is normally expected to operate. Note that the title of DES Table 4.1 indicates that these are average values. Note also that the data on which the table values are based (i.e., ER-OL Table 3.3-1) are monthly average water use rates. Comparison of the maximum system capacity and the maximum average monthly water use rate is inappropriate in terms of understanding water losses in transit in the diversion system.

Table 9.1. Records of American shad and other clupeid species in ichthyoplankton samples collected by the U.S. Fish and Wildlife Service during 1982 from the Delaware River at Point Pleasant.

1982 Date	No. of Samples	American Shad			Other Clupeids 1/	
		Eggs	Larvae	Juvenile	Eggs	Larvae
4/16	9	-	-	-	-	-
4/28	13	2	-	-	84	-
5/6	16	1	-	-	2162	156
5/13	17	2	-	-	6006	36
5/19	8	-	-	-	285	5
5/21	7	-	19	-	52	887
5/26	14	-	27	-	3	49
6/2	5	-	19	-	-	-
6/6	8	-	4	1	2	4
6/10	10	-	43	-	-	-
6/22	10	-	50	-	1	8
6/30	10	-	81	4	-	-
7/7	3	-	1	-	-	-
7/21	10	-	-	-	-	-

1/ Other clupeids probably were blueback herring or alewife.

Source: Letter dated December 21, 1983 from Edward Perry, U.S. Fish and Wildlife, State College, PA, to C. Hickey, USNRC; with 22 pages of raw tabular data (dated 3/2/83) of ichthyoplankton collected during 1982 at Point Pleasant

See also DRBC letter of 2/27/84 (Appendix O), p. 9 for additional responses.

DOI-6

DOI comments on the monitoring of metals in the Delaware.

The staff characterized the available water quality information on the Delaware River in the vicinity of the proposed intake location in terms of the range of parameter values recorded, the calculated average and median values of the data and their relationship to the applicable established water quality criteria. Where data availability was limited, the staff so stated. The staff believes that the water quality sampling program conducted by the applicant is in keeping with the guidance provided in Reg. Guide 4.2. The staff believes that the available data are sufficient in total number of samples, duration of sampling, consistency of sampling and frequency of sampling to indicate qualitatively the general conditions of the water bodies in question.

The staff believes that data on water samples or organism tissues collected from locations 15 miles upstream (i.e., a point downstream from and closer to the mouth of the Lehigh River than to Point Pleasant) and 18 miles downstream of Point Pleasant are not necessarily indicative of conditions at Point Pleasant.

Table 9.2. Species composition (by life stage and month) in ichthyoplankton samples collected by the U.S. Fish and Wildlife Service during 1982 from the Delaware River at Point Pleasant. Life Stages are: E-egg; L-larvae; J-juvenile; A-adult.

	Month in 1982			
Family/Species	April	May	June	July
Petromyzontidae sp. (Lamprey)			L	
Clupeidae sp.	E	E/L	E/L	
Alosa sapidissima (American shad)	E	E/L	L/J	L
Cyprinidae sp. (Minnows)	E/J	L/J	E/L	L/J
Cyprinus carpio (Carp)		L	L	L
Exoglossum maxillingua (Cutlips minnow)			J	
Notropis hudsonius (Spottail shiner)		L	L/J	
Notropis procne (Swallowtail shiner)			A	
Notropis spilopterus (Spotfin shiner)			J	
Notropis sp. (Shiner)				L
Catostomidae sp. (Suckers)	E/L	L	L/J	
Erimyzon oblongus (Creek chubsucker)		L	L	
Ictaluridae sp. (Freshwater catfishes)		E		
Ictalurus natalis (Yellow bullhead)				J
Ictalurus nebulosus (Brown bullhead)				J
Ictalurus punctatus (Channel catfish)			J	J
Centrarchidae (Sunfishes)				
Ambloplites rupestris (Rock bass)			L	L
Lepomis sp. (Sunfish)			L	L
Micropterus dolomieui (Smallmouth bass)			L	
Micropterus salmoides (Largemouth bass)			L	
Pomoxis sp. (Crappie)		L		
Percidae (Perches)				
Etheostoma olmstedi (Tessellated darter)		L		
Percina peltata (Shield darter)		L		
Stizostedion vitreum (Walleye)		L		

<u>References</u>

1/ Philadelphia Electric Company. "Delaware Generating Station. Materials prepared for the Environmental Protection Agency 316(b) report," 1977.

2/ Smith, D. C. and P. L. Harmon. "An ecological survey of the Delaware River in the vicinity of Point Pleasant, Pennsylvania, July 1972 - December 1973." Ichthological Associates, Inc., Pottstown, Pennsylvania, 1974.

3/ Letter dated December 21, 1983 <u>from</u> Edward Perry, U.S. Fish and Wildlife Service, State College, PA, <u>to</u> C. Hickey, USNRC; with 22 pages of raw tabular data (dated 3/2/83) of ichthyoplankton collected during 1982 at Point Pleasant.

Use of these data in place of that collected at and in the immediate vicinity of the proposed intake location is not justified.

See also DRBC letter of 2/27/84 (Appendix O) pp. 20-21 for additional response.

DOI-7

DOI comments on the concentration of phosphorous and orthophosphate in the Delaware River and its effects on the Bradshaw Reservoir and Perkiomen Creek.

The water quality data collected by the applicant from the Delaware River in the vicinity of the proposed Point Pleasant intake indicate total phosphate phosphorus and ortho phosphate phosphorus concentration peaks typically about one third of the upstream peaks mentioned in the comment (the maximum total phosphate phosphorus value shown in Table 4.4 was one of only three values in excess of 0.30 mg/l). Phosphorus loading of Bradshaw Reservoir and the East Branch Perkiomen Creek would not be expected to be as great as that indicated in the comment. As noted in FES Section 5.3.2.3, the staff believes that the introduction of the waters of the diversion to the East Branch may result in the improvement of water quality in the lower stream reaches with respect to nutrient concentration.

Any pumping of Bradshaw Reservoir waters with low dissolved oxygen concentration to the East Branch Perkiomen Creek would likely be reoxygenated as a result of passage over the outlet structure energy dissipator.

See also DRBC letter of 2/27/84 (Appendix O) p. 22 for additional response.

DOI-8

DOI addressed the potential for chemical contamination of the Bradshaw Reservoir and Perkiomen Creek from an accident on the Route 32 crossing of Tohickon Creek.

While the potential does exist for chemicals spilled into Tohickon Creek as a result of an accident on Route 32 to reach the Point Pleasant diversion, there are several design features of the diversion that provide mitigative or preventive barriers to pollutant transport to the Perkiomen Creek. The top of the Point Pleasant intake structure will have a minimum submergence of 4 ft during low river flows. Pollutants floating on the river surface would likely pass over the intake without being entrained. Additionally, the small cross sectional area of the structure and its area of influence with respect to the river cross sectional area would tend to allow much of a pollutant spill, even if dispersed in the water column, to pass without being entrained. Pollutants from a chemical spill that do find their way into the diversion would be diluted, contained and held up in Bradshaw Reservoir during the anticipated 3-day residence time before being pumped out to the East Branch Perkiomen Creek. This could provide time for the discovery of a spill, and detection of pollutant presence in the reservoir waters. Pumping from the reservoir could be suspended while the pollutants are neutralized or removed. The staff concludes that these features of the diversion adequate opportunity for prevention of spilled pollutant transport to the Perkiomen Creek.

See DRBC letter of 2/27/84 (Appendix O) pp. 22 for additional response.

DOI-9

DOI suggests that the extremes of flowrates in the Delaware should be evaluated in the impact assessment.

The flow of 3000 cfs is assumed in accordance with the present water allocation agreement between PECO and the DRBC and the DRBC's recently adopted reservoir operating rules. See also page 23 of Mr. Hansler's letter (Appendix O). The text remains unchanged.

DOI-10

DOI comments on the DRBC water withdrawal restrictions during low flowrates in the Delaware River.

In that this comment refers specifically to DRBC's intentions regarding enforcement of its withdrawal conditions, the NRC staff adopts the DRBC response found on page 25 of Mr. Hansler's letter (Appendix O).

DOI-11

DOI comments on cumulative impacts from water withdrawal in the Delaware river basin.

In that this comment refers to DRBC's procedures for allocating water supplies in the Delaware Basin, the NRC staff adopts the DRBC response found on page 26 of Mr. Hansler's letter (Appendix O).

DOI-12

DOI comments on the DRBC salinity model and on salinity levels in the Delaware Bay.

In that this comment refers to DRBC's own analysis regarding impacts on salinity levels from water allocation in the Delaware Basin, the NRC staff adopts the DRBC response found on page 29 of Mr. Hansler's letter (Appendix O).

DOI-13

DOI comments on dissolved oxygen in the Delaware estuary.

In the report, "The Delaware River Basin: The Final Report and Environmental Impact Statement of the Level B Study, May 1981," the DRBC notes the results of a study of the relationship of dissolved oxygen concentration in the Delaware estuary to flow and pollutant loadings. The conclusion of the DRBC was that pollutant loading entering this reach of the river from upstream is responsible for observed low dissolved oxygen concentrations (see Figure 12 in the above mentioned report). Operation of the Point Pleasant diversion is not expected to have any adverse effect on the pollutant loading entering this reach of the river. This issue is addressed in Section 5.3.2.3 of the FES.

See DRBC letter dated 2/27/84 (Appendix O) p. 34 for additional response.

DOI-14

DOI comments on the orthophosphate levels in the Delaware River, the Bradshaw Reservoir and the Perkiomen Creek.

See response to DOI comment 7 and also see DRBC letter dated 2/27/84 (Appendix O) p. 35 for additional response.

DOI-15

DOI recommends that the NRC environmental impact statement be revised to discuss impacts from the Merrill Creek project.

The DRBC has authority to allocate water resources in the Delaware River Basin. A draft environmental statement discussing the impacts of the Merrill Creek project was published by the DRBC. As indicated in the introductory note to these responses the DRBC has responded to these DOI comments. The NRC staff has reviewed DRBC's response to this issue (see page 36 of Appendix O) and agrees with DRBC's findings.

DOI-16

DOI addressed the adequacy of the assessment of impacts to fish and wildlife.

The DES reflected the most recent information available to the staff at the time it was prepared. It summarized the impact assessments of aquatic resources conducted during the earlier construction permit stage review, including findings made by the DRBC (See Sections 4.3.4.2 and 5.5.2).

This operating license stage environmental statement updates those previous findings in light of impacts identified earlier and recent design changes that mitigate those impacts, including operational characteristics of the intake and discharge on the Schuylkill River, and intake designs on Perkiomen Creek and the Delaware River. Impacts to the East Branch are updated and identified in detail, based on recent information, since the 1973 DRBC assessment on which AEC relied.

Entrainment of fish eggs and larvae will be an unavoidable result of withdrawals of water from those water bodies containing them, including the Delaware River. Section 5.5.2 states that the intake design will not entirely prevent entrainment, but will result in a low level of impact that will not be detrimental to Delaware River biota. The unavoidability of entrainment (and impingement) and the potential for impact from water withdrawals weighed heavily in the redesign of the structures used on Perkiomen Creek and the Delaware River. Due to the necessity to minimize impacts, modern state-of-the-art (cylindrical wedge-wire screen) intakes are to be used on those water bodies for diversion of cooling water to Limerick.

The NRC staff acknowledges, as stated in section 5.5.2.3 of the DES, that diversion of water into the East Branch will alter the upper section and change it from the present condition, resulting in loss of habitat diversity and heterogeneity of the East Branch system. This is an adverse impact and is reflected in a revised Table 6.1.

DOI-17

DOI commented that the potential for impacts on groundwater resources as a result of a Class 9 accident is worthy of analysis.

The potential impacts on groundwater resources as a result of a Class 9 accident has been addressed by the staff in the Supplement to the DES and is also contained in Section 5.9.4 of this FES.

DOI-18

In addition to commenting on the NRC staff's DES for Limerick, DOI also (1) mentioned their plans to comment on receipt of the section 404 permit from the Corps of Engineers, (2) described their actions on a Department of the Army permit to the Neshaminy Water Resource Authority and (3) described their action on permits for the Merrill Creek project.

The staff makes no response to these additional statements.

EPA-1

The first issue of this comment is concerned with the treatment of EPA radiat ion protection standards in the DES.

The U.S. Nuclear Regulatory Commission, on May 5, 1975, issued Appendix I, Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion "As Low As Is Reasonably Achievable" for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents, 10 CFR Part 50. The rule was the result of a detailed review by the Commission of the record of the public rulemaking proceedings which began in January, 1972.

The U.S. Environmental Protection Agency, on January 13, 1977, issued 40 CFR Part 190, Environmental Radiation Protection Standards for Nuclear Power Operations, pursuant to the Atomic Energy Act, as amended, and Reorganization Plan No. 3 of 1970, which gave the EPA the authority to set radiation standards. The parts of these standards affecting nuclear power plant facilities went into effect December 1, 1979 and the standards for krypton-85 and iodine-129, were effective January 1, 1983, for any such radioactive materials generated by the fission process after these dates.

The NRC has been issuing radioactive effluent and environmental monitoring Technical Specifications in accordance with the original proposed Appendix I guidance of 1971 and the Appendix I as issued May 5, 1975, for nuclear facilities as they were licensed or as their Technical Specifications were amended. The NRC has also been in the process of developing a standardized radiological effluent and environmental technical specification to implement Appendix I to 10 CFR Part 50 (NUREG 0473).* These NRC standardized specifications for Boiling Water Reactors (BWRs) must now assure that 40 CFR Part 190 is implemented.

*U.S. Nuclear Regulatory Commission, NUREG-0473, "Radiological Effluent Technical Specifications for BWR's Rev. 2, February, 1980.

The Appendix I Technical Specifications for single unit sites require a report within 30 days if the effluent releases exceed one-half the annual design objectives in a calendar quarter. For multi-unit sites, such as Limerick, the reporting requirement is reached at one-fourth the design objective value in a calendar quarter. Absolute upper (shutdown) limits of radioactive releases are based on 10 CFR Part 20 doses and concentrations.

10 CFR Part 20, Article 20.106, Section (g) also requires operators of commercial nuclear power plants to comply to the 40 CFR Part 190 standards as follows:

> "In addition to other requirements of this part, licensees engaged in uranium fuel cycle operations subject to the provisions of 40 CFR Part 190, "Environmental Radiation Protection Standard for Nuclear Power Operations," shall comply with that part."

As long as a nuclear plant site operates at a level below the Appendix I reporting requirements, no extra analysis is required to demonstrate compliance with 40 CFR Part 190. If a site's Appendix I reporting requirement dose level is reached or exceeded, the Technical Specifications require an analysis to be performed to determine if any additional limitations will be necessary to ensure continued compliance with 40 CFR Part 190.

Based on experience, most Technical Specification reporting levels are not exceeded by substantial amounts. Thus, in most situations, it should be possible to demonstrate continued compliance with 40 CFR Part 190 by reevaluating the exceeded Appendix I design objective dose using more realistic assumptions. This approach is not only permitted but encouraged since 40 CFR Part 190 applies to real individuals. Appendix I to 10 CFR 50 lists design objective doses which may or may not apply to real people.

For more details on the above topic the commentor is referred to an NRC document entitled: "Methods for Demonstrating LWR Compliance with the EPA Uranium Fuel Cycle Standard (40 CFR Part 190)" - NUREG-0543.* This document presents the specifications that implement 40 CFR Part 190 and Appendix I to 10 CFR Part 50. It also explains the rationale for using Appendix I to demonstrate compliance with 40 CFR Part 190 for sites with four or less nuclear power reactors and describes acceptable methods for demonstrating compliance with 40 CFR Part 190 for sites whose radioactive effluents exceed the Appendix I portion of the specifications.

For the above reasons the NRC staff does not feel that it was necessary to address the 40 CFR Part 190 standards in their entirety in a tabular form in the DES or the FES. The staff's position as stated in NUREG-0543 is that as long as a nuclear plant site operates at a level below the relatively more conservative Appendix I dose design objectives and reporting requirements, it will be operating in compliance with 40 CFR Part 190. The staff has revised Section 5.9.3.2, of the DES to incorporate EPA's comment into the FES and to provide a rationale for using the Appendix I dose design objectives to demonstrate compliance with EPA's 40 CFR Part 190 standards.

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*--------, NUREG-0543, F. Congel, "Methods for Demonstrating LWR Compliance With the EPA Uranium Fuel Cycle Standard (40 CFR Part 190), February, 1980.

As for the second issue, the EPA Comment No. 1 refers to the information presented in Table 5.12. The commenter expresses some doubt as to whether the applicant will be able to meet the EPA's 40 CFR Part 190 standard for the release of krypton-85 during normal operation of the Limerick facility.

Table D-1, of the Limerick DES, has already presented the calculated release of krypton-85 from the Limerick facility as 240 Ci/year per reactor. This release rate is about 0.5% of the EPA standard of maximum release of 50,000 curies of krypton-85 entering the general environment from the entire uranium fuel cycle, per gigawatt year of electrical energy produced by the fuel cycle.

The curies of tritium, carbon-14, krypton-85, and iodine-129, given in Table 5-12 of the DES, represent the total curies of each contained in 35 metric tons of spent fuel (the annual reference reactor fuel requirement), irradiated to 33,000 MWd/MT, and aged 5 years. The EPA regulation, 40 CFR 190.10, requires that, for krypton-85 and iodine-129 generated by the fission process after January 1, 1983, releases to the environment from the entire fuel cycle, per gigawatt-year of electricity generated by the fuel cycle, must be less than 50,000 curies of krypton-85 and 5 millicuries of iodine-129. For the releases shown in Table 5.12, this means that about 90% of the krypton-85 and 99.7% of the iodine-129 would have to be captured before reaching the environment. Since the steps to comply with this regulation have not yet been specified, the staff did not reduce the Table 5.12 estimates which are based on 100% release. Similarly, because the site and method for spent fuel disposal have not yet been defined, and methods of capturing iodine-129 and krypton-85 before release have not been specified, the NRC staff cannot determine what amounts of radionuclides may eventually escape from the repository or when they may enter the environment. However, the NRC staff has identified which radionuclides have the higher probability of migrating from a repository, and which of these radionuclides are the principal contributors to environmental dose commitments if they do eventually enter the biosphere. In general, the gaseous radionuclides that escape from failed fuel rods, or leaking waste canisters before the repository is sealed, and the very long-life radionuclides that have low retardation in soils, such as iodine-129, which may migrate with groundwater and eventually reach the biosphere, are the principal contributors to environmental dose commitments. Accordingly, to estimate the upper bounds of prospective dose commitments the worst case assumptions have been made in Table 5.12 that spent fuel will be reprocessed and that all of the tritium, carbon-14, krypton-85, and iodine-129 contained in 5-year-old spent fuel per RRY of the model BWR have been released to the environment.

The potential radiological impacts of the supporting fuel cycle are summarized in Table C-5 of Appendix C of the Limerick FES for an environmental dose commitment time of 100 years. From the risk analysis in Appendix C, the staff concludes that, in spite of the extreme conservatism involved in the source terms assumed for tritium, carbon-14, krypton-85 and iodine-129, both the dose committments and the health effects of the LWR-supporting uranium fuel cycle are very small when compared with dose commitments and potential health effects to the U.S. population resulting from all natural background sources.

Therefore the NRC staff feels that having considered the worst case, any realism factored into the risk analysis, such as the small liklihood of spent fuel being reprocessed in the U.S. in the near future and the containment of 90% of the krypton-85 would only improve an already acceptable situation.

As stated in the response to EPA-1, 10 CFR 20.106(g) would still require the applicant to comply with the 40 CFR 190 standards. Therefore the applicant will have to take the measures necessary to prevent at least about 90% of the krypton-85 and 99.7% of the iodine-129 inventories shown in Table 5.12 from escaping into the environment.

EPA-2

EPA stated that the radwaste issues to be addressed in the SER and the severe accident issues to be addressed in a Supplement to the DES should be considered as a part of the NEPA process.

The staff's position is that the DES/FES adequately discusses the radwaste systems to meet the requirements of 10 CFR 51 and that the reference to the SER was provided as a source of further information. The postulated accident analysis was covered in DES Supplement No. 1. EPA commented on Supplement 1 as indicated later in this section.

EPA-3

EPA commented that at least a general order of magnitude of the impacts of decommissioning should be discussed.

The radiological impacts of decommissioning a reference boiling water reactor (BWR) are discussed in NUREG-0586, Draft Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities. Section 5.11 of the DES had already discussed and referenced NUREG-0586 as a source of estimates for these impacts. In particular, Section 5.3 of NUREG-0586 presents estimates of radiation doses to plant workers and to members of the public for decommissioning of a reference BWR. Section 5.11 of the DES has been revised to incorporate EPA's comment into the FES and to specifically refer to a particular section of NUREG-0586 which presents and discusses estimates of radiation doses to the public and to the workers.

EPA-4

EPA presented questions on the Delaware River water withdrawal rates.

The 46 mgd of water diverted to Limerick from the Delaware River is in excess of the amount needed for withdrawal at the Graterford intake on Perkiomen Creek, due to approximately a 10% seepage and evaporative loss of water in transit through the transmission pipelines, the East Branch (35.7 km) and main stem of Perkiomen Creek (3.6 km). See FES Section 4.3.1.2 for a thorough discussion of Limerick's water use.

Table 4.1 shows the overall averages and range of average monthly water use rates for Limerick. The makeup flow of 57.4 ft^3/sec (37 mgd) is the maximum monthly average makeup water flowrate to be withdrawn from Perkiomen Creek, where the Graterford intake structure is designed to be able to withdraw up to 40 mgd. See FES Section 4.3.1.2 for a thorough discussion of Limerick's water use.

EPA-5

EPA commented that Section 4.2.4 should detail the current conditions of the streams to receive diversion water more thoroughly.

Hydraulic surveys of the East Branch of Perkiomen Creek have been performed by the applicant in 1970, 1972 and 1979. The computed changes in flow characteristics due to pumping as a result of these surveys are described in the applicant's Environmental Report - Bradshaw Reservoir, Transmission Main, East Branch Perkiomen, and Perkiomen Creek, July 1979 submitted to the DRBC. The impacts of the increased flow on the biota of the East Branch of Perkiomen Creek are assessed in Section 5.5.2.3 of the FES based on a review of available information. The possible effects of the diversion on sedimentation and erosion in the East Branch of Perkiomen Creek are described in Section 5.3.3.3 of the FES.

EPA-6

EPA comments that no mention is made of the effects of the Pennsylvania PUC decision regarding Unit 2.

The application presently before the Commission is for operation of two nuclear units at the Limerick site. Therefore, the environmental impact assessments by the NRC in this case are based on two-unit operation.

EPA-7

EPA addresses the need for water releases from the Merrill Creek facility.

As stated in Section 4.3.1.1.3 of the DES, releases from upstream reservoirs are capable of maintaining a flow at 3,000 cfs at Trenton during a moderate drought in the Delaware River Basin.

Sufficient storage capacity (not including Merrill Creek) and operational procedures are planned to maintain flows of 2500-2900 cfs at Trenton should a drought of the severity of the 1960's occur. The estimated recurrence interval of a drought of this severity is 100 to 300 years. The restrictions on the use of Delaware River water imposed by the DRBC do not permit pumping for diversion to Limerick when such pumping will reduce the flow at Trenton to below 3000 cfs unless compensating flows are released by the applicant from a non DRBC sponsored project (such as Merrill Creek Reservoir).

It is the staff's position that compensating releases from Merrill Creek would only be required for operation of the plant during a drought that would probably not occur during the life of the plant. Furthermore, any shutdowns that might occur due to water unavailability during a severe drought will be considerably less frequent over the life of the plant then shutdowns due to other causes.

EPA-8

EPA addresses salinity levels in the Delaware up to the year 2000.

DRBC has analyzed the effects on salinity levels of water allocations in the Delaware Basin. Because Limerick's withdrawal is only a small percentage of even the minimum river flow to be maintained at Trenton, the effects of this withdrawal on salinity levels are expected to be insignificant. See DRBC's response to the Department of the Interior's (DOI) comments (Appendix O).

EPA-9

EPA sees apparent inconsistencies in Sections 4.3.2.1 and 5.3.2.2 with respect to changes in the overall scheme for water use.

The statement in section 4.3.2.1 of the DES regarding the overall station water use scheme refers to the continued planned use, at the operating license stage from the construction permit stage, of a closed cycle cooling system, natural draft cooling towers for heat dissipation and the use of the Schuylkill River as a source of cooling water, to be supplemented as necessary by the Point Pleasant diversion. The changes referred to in section 5.3.2.2 are to specific systems or components within the unchanged overall water use scheme or to analyses of effects on the environment due to these design finalizations or to account for updated environmental data. These changes are described fully and clearly in Sections 4 and 5 of the FES.

EPA-10

EPA sees an apparent inconsistency between DRBC and DES conclusions on the benefits of diversion to the East Branch Perkiomen.

The conclusions of the NRC staff, the DRBC and the PaDER are in agreement with regard to the expected effect of the Point Pleasant diversion on water quality in the lower reaches of the East Branch Perkiomen Creek. That is, introduction of Delaware River water will result in a diluting of the waste loads carried by the stream in its lower reaches, because the Delaware River water is generally of higher quality than these stream waters. However, in striking the cost-benefit balance for LGS, the staff has not included this effect as a benefit of the proposed facility operation, consistent with the DRBC position in Docket D-65-76CP(8). Only the direct LGS benefits of electrical energy production, and creation of additional generating capacity were considered.

EPA-11

EPA discusses the potential for the effects of flash floods to be exacerbated by the diversion flow.

Natural stream flows in the East Branch of Perkiomen Creek and inflow from the Bradshaw Reservoir will be monitored by a stream gage which has been installed at Bucks Road just downstream of the Bradshaw Reservoir discharge point. Stream flow data from this gage will be telemetered to the Limerick Station and an alarm will be activated at a predetermined flow. At that time, the Bradshaw Reservoir pumps, if operating, will be shut down.

The flow at the gaging station which will activate the alarm will be set such that (1) diversion from the Bradshaw Reservoir does not aggrevate an existing flood condition on Perkiomen Creek (or the East Branch), and (2) the diversion does not unnecessarily augment flows in Perkiomen Creek when not required.

EPA-12

EPA suggests that concentrations in air of certain pollutants should be given.

Based upon releases from identical boilers that are being operated by PECO at the Peach Bottom Atomic Power Station, the applicant has estimated the potential air releases (documented in applicant's response to NRC question E451.6) from the operation of the auxiliary boilers at the Limerick Generating Station. The following table provided by the applicant presents the expected annual releases from these boilers, as compared to the deminimus release levels (EPA criteria) below which no Prevention of Significant Deterioration assessments (off-site impact assessment) are required by regulation because the off-site impacts from these releases are minimal:

Pollutant	Deminimus (tons/yr)	Estimated Emission (tons/yr)
SO_2	40	28.2
NO_x	40	14.3
particulate	25	1.3
ozone	40	0
lead	0.6	0
CO	100.0	3.3

Since the anticipated releases are well below deminimus levels, no off-site assessment is needed.

EPA-13

EPA comments on the mitigation of potential impacts from cooling tower chlorination.

The staff has identified potential impacts to aquatic resources from cooling tower chlorination and practicable alternatives for their control. These impacts have not been found to be of such magnitude as to tip the cost/benefit balance to a negative finding. A determination of the mitigative actions that will be implemented is within the authority of the Commonwealth of Pennsylvania (Pa DER) as it implements the provisions of the Clean Water Act through the NPDES permit. Because this permit has not yet been issued, any discussion in the FES would be inappropriate.

EPA-14

The NRC staff agrees with the comment that eels are present in the Delaware River. In addition to the small eel fishery upstream of Point Pleasant (as stated by EPA), eels are known to pass the Fairmont Dam fishway of the Schuylkill River at Philadelphia (Personal communication between C. Hickey, NRC, and M. Kaufmann, Pennsylvania Fish Commission, May 5, 1983) as they ascend the Schuylkill from the Delaware River. Eels also are recorded in samples of ichthyoplankton, entrainment, and impingement at the Delaware Generating Station on the Delaware River in Philadelphia.[1] Eels also have been captured by several gear types at Point Pleasant.[2]

(References listed following Table 9.2.)

EPA-15

EPA comments that monitoring of streams receiving diversion water should be carried out.

The sections of this environmental statement related to diversion of cooling water through the East Branch Perkiomen Creek (Sections 4.3.4.2.2 and 5.5.2.3) discuss the present status and "bioindicators of environmental conditions" (Tables 4.6 and 4.7) of the creek, against which to measure future conditions after diversion. Based on the projection of environmental changes (physical; water quality; biotic) to the East Branch resulting from diversion, it would be useful to monitor the creek following the onset of diversion. Any requirements for environmental monitoring of the East Branch would be the responsibility of either the Commonwealth of Pennsylvania or the Delaware River Basin Commission. Monitoring related either to power plant discharges (chemical/thermal) to the Schuylkill River or to cooling water intake withdrawals from the Schuylkill River are the purview of the Commonwealth under authority of the Clean Water Act (See Sections 1.2 and 5.14.2). On September 2, 1982, the Pennsylvania Department of Environmental Resources issued a Water Obstruction and Encroachment Permit No. ENC:09-81 to the Neshaminy Water Resources Authority, for construction and maintenance of the water intake structure at Point Pleasant on the Delaware River. Special Condition "U" requires the permittee to monitor the ecology of the river and the operation of the intake and to report the findings on a regular basis.

EPA-16

EPA suggests reassessment of phosphorous and sedimentation control due to the Bradshaw Reservior.

There are no claims made by the NRC regarding sediment control by the proposed Bradshaw Reservoir. FES Section 5.3.2.3 only cites conclusions made regarding nutrient removal and particulate settling by the DER and DRBC. The effects of the diversion on phosphorus loading of the East Branch Perkiomen Creek is discussed in Section 5.3.2.3.

EPA-17

EPA notes an inconsistency in the last paragraph on page 5-25 concerning "...induced shock will adversely affect biota along the Limerick Transmission Corridor."

This inconsistency was also noted by PECo. It has been corrected as noted in the response to PECO-13.

Responses to DES Supplement Comments

PECO-1

PECO states that inappropriately large conservatisms have been incorporated in the DES analysis, and that risk is more accurately estimated in their Severe Accident Risk Assessment.

The staff agrees that some elements of excessive conservatism were present in the DES, and revisions have been made in the analyses for use in the FES. For reasons outlined in Appendix N, the staff does not believe the methods used by the applicant to assess risk are sufficiently accurate, however.

PECO-2

PECO states that "some of the source terms in the DES are higher than any in other prior environmental statements, probabilistic risk assessments, or source term analyses. They are also higher than those estimated in the SARA. The use of such large source terms contributes to calculated consequences that are essentially upper bounds. It would, therefore, appear to be unnecessary to include additional quantitative uncertainty or sensitivity analysis."

It is the staff's opinion that upper bounds can only be obtained by adjustment of all variables used in a computation, and it would be inappropriate to assume that calculations in which only a few of many contributing factors were extremely large could be treated as upper bounds. The staff has recognized the difficulty in quantifying the uncertainty of risk estimates, and the graphic displays and discussions of uncertainties have been further modified to improve clarity and avoid misinterpretation.

PECO-3

PECO suggests that median estimates of frequencies are to be preferred. Means or point estimates are just summary measures of a state of knowledge, and the staff does not agree that use of the means in PRAs are any less appropriate than use of the medians. The staff's safety goal evaluation plan described in Federal Register Vol 48, pp 10773-10781, March 14, 1983 does not preclude use of values other than the medians in PRAs. Further, the staff's safety goal sensitivity studies would include the impact of using mean, median, or 90th percentile values to state the safety goals.

Median frequencies were used in the environmental statements for the plants cited in the comment because at the time of analysis for these plants, only the median frequencies were available.

PECO-4

In regard to the staff's use of its contractor report, NUREG/CR-3028, PECO states that

> "The staff has used the NUREG/CR-3028 point estimates, which we believe are incorrect, for internal events in the DES analysis. Four issues, identified to the staff at our meeting of September 26, 1983 (Reference 1 of attachment), have not been addressed by the DES. These issues are:

Recovery of Feedwater, Loss of Offsite Power Initiator Frequency, HPCI Restart Failure Probability, and Failure of Manual Depressurization."

PECO correctly observed the staff's use of Draft-NUREG/CR-3028 estimates for the human unreliability and the frequency of specific initiating events. At the time of the preparation of the Limerick DES, the values from Draft-NUREG/CR-3028 appeared to be the best estimates available. Meanwhile, the staff has continued its review of these frequencies and is using the following best estimate of the appropriate frequency values in the Limerick FES:

Recovery of Feedwater: Same as NUREG/CR-3028
Frequency of Loss of Offsite Power: 0.097/RY (Mean)
HPCI Restart Failure: Same as NUREG/CR-3028
Failure to Manually Depressurize: Same as NUREG/CR-3028

PECO-5

The alternative of using conservative source terms and deleting quantification of uncertainties was suggested by PECO. See the response to PECO-2.

The staff believes that the uncertainties should be inseparable from the quantitative results of the Limerick SARA.

PECO-6 and -7

PECO states that both the assumed power level and the associated core fission product and activation product inventories used by the staff are inappropriate for the Limerick reactor.

The staff normally assumes a BWR power level of 105% of the proposed license limit, and uses the distribution of fission and activation products presented in Appendix VI of WASH-1400, suitably scaled by the assumed power level, for severe accident analyses in environmental statements. This practice is not the result of conservative approximation, but may be supported by several considerations arising from the necessity of modelling a reactor inventory by a single uniform distribution.

The radioisotope composition varies markedly with location within the core, with time within each refueling cycle, with the fuel management system chosen, and with the reactor's power history. In the event of a severe core-damaging accident, it is likely that fission product releases would be greater from the portions of the core having the highest recent power density than from the core periphery. The staff, therefore, considers it reasonable to assume an elevated power level to account for such power density distributions.

It is the staff experience that the computer programs used to estimate core inventories differ, for some isotopes, both among themselves and with post-irradiation measurements by factors larger than those by which the staff's and the applicant's estimated inventories disagree. These differences are largely due to approximations that are necessary in making the computations. Even were these computations to be done exactly, however, it would not be possible to predict reliably the power distribution history during the years of operation in which the inventory is to be generated at Limerick. The chief bias in the staff's estimated inventory arises from assuming the inventory to be that at the end of a refueling cycle following uninterupted full power operation, rather than assuming equal likelihood of an accident at any other time during the cycle.

The staff has compared the inventories used here, in Table 5.11a, and in Table 7.1-24 of the ER-OL with available computations. Except for the activation products which were not calculated for the ER-OL, there is reasonably good agreement. In the staff's opinion, both the fission product inventories used in the environmental statements and in the ER-OL are adequate for use in risk analysis and would not yield significantly different estimates of risks. Since no other inventory has been found to be more suitable for use in Limerick analyses, the FES assumes the same inventory as did the DES.

PECO-8

PECO feels that the source terms are conservatively treated by the DES analysis contrary to the "improvements" suggested by the statement in Section 5.9.4.5(2) of the DES supplement.

This comment is appropriate only in that the statement presented in the DES could have been expanded to define the improvements made to the assessment methodology after publication of the RSS.

Basically, all of the improvements were related to the assessment of core meltdown phenomena and the response of the containment building.

The chemical form and quantity of fission products released from the fuel was purposely made consistent with the RSS. In a similar manner, the NRC staff's treatment of primary system retention, suppression pool scrubbing, and agglomeration and settling of the fission products was not "improved" relatively to the RSS. However, it is not clear that this procedure always results in "conservative" source terms as the PECO comments imply. The staff believes that for some sequences the above procedure resulted in lower fission product release fractions than calculated using the "improved" methods in the LGS-PRA or LGS-SARA.

PECO-9

PECO states that the use of mean frequencies by the staff results in much more conservative risk estimates than have appeared in other staff analyses.

It is the staff's opinion that the use of mean frequencies together with portrayal of uncertainty in the results stemming from the use of the mean provides a similar risk perspective as would the use of median frequencies coupled with portrayal of uncertainty in the results stemming from use of the median. (See also the response to PECO-3.)

PECO-10

PECO stated that

> The use of an effective peak ground acceleration of 0.4g as the dividing line between severe earthquakes and earthquakes of low to medium severity is conservative. At that level of acceleration there would likely be only a small number of, if any, bridge or

overpass failures, and complete disruption of the road network is not expected.

The applicant in the LGS-SARA has indicated that Modified Mercalli Intensity (MMI) scale IX is the boundary level below which evacuation would not be impeded by earthquakes. The applicant assumed that MMI Scale IX corresponds to an effective peak acceleration (EPA) of 0.61g. The staff agrees that MMI Scale IX is a reasonable dividing boundary, but found that an EPA of 0.61g is not an appropriate value to be used. While there is a wide scatter in the correlation between intensity and acceleration, a reasonable choice can be made providing that it is consistent with the assumptions made in the LGS-SARA itself, and in recent investigations.

In the LGS-SARA, reference is made to Kennedy (1981) to justify the use of an upper bound EPA. In that work Kennedy assumed that MMI Scale IX is associated with an EPA of 0.4g-0.5g or less. Recent investigations also indicate a lower EPA than 0.61g for MMI Scale IX. For example, Krinitzsky and Marcuson (1983) proposed a mean acceleration of 0.48g (0.28g EPA) for MMI Scale IX at a near-field, hard rock site. Similarly, in an LLNL (1984) report, a survey of various intensity acceleration correlations resulted in a median acceleration of 0.35g (0.28g EPA) to be associated with epicentral intensity MMI Scale IX. In accord with the assumptions in the LGS-SARA, the EPA is derived from the peak acceleration by multiplying it by a factor of 0.8.

Based on the above, the staff concludes that an EPA of approximately 0.4g should be used to characterize MMI Scale IX. The staff concludes that this value is more consistent with both the assumptions used in the LGS-SARA itself and recent investigations.

References

Krinitzsky, E. L. and W. I. Marcuson III, 1983, Principle for Selecting Earthquake Motions in Engineering Design, Assoc. of Eng. Geol. Bull. V.xx, pp. 253-265.

Lawrence Livermore National Laboratory, 1984, An Empirical Assessment of Near-Source Strong Ground Motion for a 5.5 m_b Earthquake in the Eastern U.S. Technical report submitted to NRC by R. Campbell.

Kennedy, R., 1981, Comments on Effective Ground Acceleration Estimates for the Indian Point Site, Structural Mechanics Associates, Inc.

PECO-11

PECO states that it is excessively conservative to assume that 24 hours would be required for population relocation following an earthquake having 0.4g peak acceleration.

The staff believes that it is possible for some people to relocate less than 24 hours after plume passage. However, in the absence of specific emergency planning for the special case of an earthquake-caused nuclear accident, there is a strong possibility that many or most people will not effectively relocate for 24 hours or more. For earthquakes of Intensity IX or greater on the Modified-Mercalli Scale (the ground acceleration associated with this intensity is discussed in the staff response to PECO-10), effects that might impair radiological emergency response includes the splitting of emergency response resources between earthquake recovery and nuclear accident dose mitigation; impairment of public notification systems; road blockages; damage of autos in or near collapsing structures; people staying behind to help in the earthquake rescue effort; liquefaction of roadbeds; and water and gas leakage that might impede travel. The staff also notes that the same assumed relocation time was used in the staff evaluations of severe accidents at the Zion and Indian Point reactors.

PECO-12

PECO states that the staff's assumed radioisotope inventory is inappropriate for a BWR. See the responses to PECO-6, -7, and -38.

PECO-13

PECO states that there are significant differences between the applicant's release fractions presented in SARA and those assumed in the DES.

The staff has reconsidered its release fraction assumptions, and the disparity between the SARA analysis and the staff's analysis has been reduced by the downward revision of the release fractions for some of the release categories. See Table 5.11.c.

PECO-14, -15

PECO feels that the DES source terms for some releases exceed any in the RSS.

The high release fractions of iodine and the cesium group have been reduced in the staff analysis of some of the release categories.

PECO-16

PECO states that steam explosion source terms containing 40-50% ruthenium can only come about in the event that 50% or more of the core is involved in a steam explosion; such steam explosions were not considered in earlier FESs; therefore, the LGS has been treated more pssimistically than other BWRs in previous FESs.

The staff listed seven steam explosion release categories in Table 5.11c of the DES supplement. However, from an inspection of Table 5.11d on page 5-18 of the DES supplement, it will be noted that the staff omitted six of these releases from the consequence analysis because of their low probability and insignificant contribution to risk. Note also that the release fractions for these six steam explosion release categories were not calculated by the staff or their contractors at BNL, but were taken directly from the LGS-PRA (refer to Appendix H, Table H.4 of the DES). The authors of the LGS-PRA in turn took these source terms directly from Appendix V of the RSS.

The only steam explosion release category in Table 5.11c that was actually used by the staff in the consequence analysis was I-T/SE. Note also (by reference to Appendix H, Table H.4 of the DES) that this is the one release category that was considered to be inappropriately used in the LGS-PRA. In the LGS-PRA, this failure mode was allocated release fractions similar to release category BWR-1. This release corresponds to an ATWS sequence analyzed in Appendix V of the RSS, in which the steam explosion was assumed to occur after only 13% of the core had melted. Consequently, most of the BWR-1 melt release in the RSS would be released to containment without pool scrubbing. For the I-T/SE release, the NRC staff would expect a steam explosion after a much greater fraction of the core has melted, and thus would expect most of the melt release to be scrubbed in a subcooled pool. Consequently, the I-T/SE steam explosion release fractions used by the staff in the consequence analysis were lower than the release fractions suggested by the LGS-PRA authors for the equivalent release (namely, $C_1\alpha$).

PECO-17

This comment observes that Limerick appears to have been treated more pessimistically than any other BWR previously analyzed by the staff.

The staff did not intend to treat LGS more pessimistically than other BWRs. The staff intent was to use a methodology consistent with that used for previous FESs, but which fully considered insights gained from the plant-specific PRA. This methodology did result in some very large release fractions for some release categories which, upon reconsideration, have been revised downward. The staff has no comment on whether or not the RSS methodology is conservative with respect to source terms until the peer review of the methodology development being coordinated by the NRC Accident Source Terms Program Office is complete.

PECO-18

PECO observed that from inspection of the frequency values in Table 5.11d, it is apparent that changes in the containment event trees for hydrogen burn, steam explosion, and SGTS operation from the LGS-PRA or NUREG/CR-3028 have been made. The changes and their bases have not been provided. For Class II and Class III, the DW and WW failure modes were combined with the $\overline{WW}$ failure since the staff assumed a pool decontamination factor of one for saturated pools. This yields a conservative evaluation.

The use of a pool decontamination factor of one for saturated pools is consistent with the use of RSS methods. Under these circumstances, differences between the DW, WW, and $\overline{WW}$ failure modes will not be large for a given accident class. However, we should note that the LGS-PRA binning of all Class II and III failure modes into a Class I failure mode (OPREL) is definitely nonconservative.

PECO-19

This comment on Table 5.11d objects that the staff did not correct NUREG/CR-3028 as they had suggested at an earlier meeting, and that the staff selected 0.4g rather than 0.61g as the effective peak ground acceleration above which earthquakes were to be considered severe.

See responses to PECO-4 and PECO-10.

PECO-20

PECO comments on Section 5.9.4.5(2) that

> "The use of a single delay time (2-hr) is not as realistic as the model used in SARA. The DES criticizes the SARA model because it is

'not site specific. However, the staff has used the same model in other FES' (e.g., Susquehanna, NUREG-0564)."

The staff used three sets of emergency response assumptions, as listed in Table 5.11f. The generic model used in SARA was proposed by Sandia as adequate for use where site-specific information was lacking. In the case of Limerick, site-specific information was available and, as discussed in Appendix N, was used with some modifications which resulted from the staff review. The criticism of the SARA model as "not site specific" refers to the assumption of the 10-mph evacuation speed, which is much larger than the referenced NUS study of the road network and expected traffing loading could justify.

PECO-21

PECO comments on Section 5.9.4.5(2), that limiting the ability to effectively evacuate is not unreasonable, but assuming no evacuation for the population around the site is overly conservative.

It is the NRC staff's judgment that the ER-OL value of peak ground acceleration 0.61g for the threshold of the degree of severity of physical/structural damage associated with a Modified Mercalli intensity scale value of IX or higher is somewhat optimistic. The staff assumed a peak ground acceleration of 0.4g, typical of the 0.35g to 0.50g range, would be more appropriate for the onset of seismically induced source terms. The staff also judged that, for conditions of substantial seismic damage to structures and roadways reasonably early evacuation would be difficult to achieve. The staff, therefore, assumed no evacuation for these situations. Rather, relocation of people from highly contaminated areas 24 hours after plume passage was judged to be a reasonable assumption. Refer also to the responses for PECO-10 and -11.

PECO-22

PECO commented on Section 5.9.4.5(3) and the double asterisked note that the DES utilized mean frequencies for the various accident sequences and categories rather than medians. The mean for a positively skewed distribution such as the log normal corresponds to a confidence level well above the median and could correspond to confidence levels as high as 80-90 percent. The median which represents the value where there is an equal likelihood of being greater or less is considered to be a more appropriate measure of risk. (Susquehanna, Fermi-2, and Byron PRA's utilized median frequencies in their analysis rather than means.) While the impact of this is small for internal initiators, it is large for the seismic initiators where the mean is almost a factor of 20 higher than the median.

See response to PECO-3.

PECO-23

PECO comments on Figures 5.4.b to 5.4.g and Table 5.11g that

"The results shown are more severe than presented in the LGS SARA. This is due to the higher frequencies, higher release fractions, and more pessimistic emergency response. The major difference is in the CCDF for early fatalities (Figure 5.4e) which lies above the upper

95% curve from SARA. The represented upper confidence levels (cross hatched areas) are not substantiated and are unprecedented for any assessment of risk. It is difficult to believe that these are plausible outcomes at any but the most extreme (much greater than 99%) confidence levels."

Errors in the class IV transient and LOCA release fractions, and in the use of off-site power and fire-damage frequrencies have been corrected. While judgment as to confidence that experts may have of the higher or lower values any particular estimate often exist, statistically valid confidence limits of CCDFs are not possible. The cross-hatched areas in Figures 5.4b to 4.5g have been removed because they were subject to misinterpretations, such as PECO's mistaking them as confidence levels. The cross-hatched areas were derived by assuming that all probabilities and consequences could have values ranging from ten times their estimated values to zero, and the association between consequences and their probabilities could be random. Under these assumptions, no consequence in any permutation could fall outside the cross-hatched area. As evidenced by this comment, this display offers no benefit in proportion to its susceptability to misinterpretation, and has been deleted.

PECO-24

PECO commented on Figures 5.4b to 5.4g and Table 5.11g that

"The early fatality risk associated with Limerick, based on this analysis, is dominated by extreme seismic events of rare occurrence. It is particularly important to point out that the postulated seismic event in addition to inflicting damage on the Limerick site would cause substantially higher fatalities directly to the population (through falling debris, building structural failures, etc.) than are attributed to Limerick related causes. Regardless of Limerick operation, substantial risk to the population exists from large magnitude seismic events. This issue can be addressed if the risk to the population associated with a large magnitude seismic event is displayed along with the incremental risk associated with such an event during Limerick operation. It would then be apparent that the incremental risk of Limerick operation would be negligible."

Detailed studies of non nuclear-related earthquake risk for the Limerick site and most of the Eastern U.S. have not been carried out. Extrapolations of estimates of fatalities due to severe earthquakes in California and South Carolina indicate that these fatalities may be on the order of thousands of individuals. These estimates are of the same order as those calculated fatalities resulting from a severe earthquake-induced core melt as presented in the DES and FES. They are gross extrapolations that do not take into account the specifics of the Limerick site and its surroundings. At this point, however, it appears premature to support the intuitive argument that the earthquake-related risk resulting from the presence of a nuclear power plant at Limerick is negligible compared to the general earthquake risk.

PECO-25

PECO comments on Section 5.9.4.5(7) that differences between the PRA frequencies and those developed by BNL were not discussed, and that the BNL core melt frequency should be reduced on the basis of more recent assessments.

At the time of the preparation of the Limerick DES, the values appearing in the draft copies of NUREG/CR-3028 obtained from BNL were, in the staff's opinion, the best estimates then available. Since then, further work has produced an improved estimate of the loss of off-site power frequency, which has been used in the preparation of the FES.

PECO-26

PECO objects to the characterization in the DES Section 5.9.4.5(7) of the confidence limits of the applicant's accident probabilities appearing in the SARA. The staff has revised the text to clarify the criticism.

PECO-27

PECO comments that Section 5.9.4.5(7) that "The Staff's analysis of accident probabilities uses only a point estimate. The EROL (SARA) does consider the uncertainty in seismic probability in detail in making its assessment. The DES provides no adequate justification for its use of point estimates, particularly in the seismic events."

While the section referred to in this comment has been revised in the FES, the staff's method of treating seismic probability is unchanged. The staff has chosen point estimates of seismic probabilities, and has assessed the ranges of risks corresponding to the uncertainty of those probabilities. It is the staff's opinion that no more is known aobut the uncertainties of seismic probabilities than is known about the probabilities themselves, and that more detailed uncertainty assessments add computational cost without any corresponding benefit.

PECO-28

PECO comments on Section 5.9.4.5(7) that "A comparison is made of the DES core melt probability with published PRAs. This is inconsistent and presents an unfair comparison because the values from other plants are from the published PRAs not from staff or staff contractor reviews."

It is true that the appropriateness of the comparison may be in question, as also stated in the DES paragraph under reference. This is due to differences of approach, assumptions and methodology. However, all the studies have analyzed the internally initiated events in a similar manner. The core melt probability uncertaintly bound comparison is made for illustrative purposes only. It is not meant to be an indicator of relative plant safety.

PECO-29

PECO comments on Section 5.9.4.5(7) that staff has disregarded the Limerick specific analysis contained in NUREG/CR-3028, the LGS-PRA, or SARA with regard to source terms development.

The staff contractor-generated source term estimates for Limerick (NUREG/CR-3028) have been revised. Further, the staff has reviewed the material in the LGS-PRA, SARA, other industry efforts, and NRC sponsored research on the subject. (See also responses to PECO-33 and -34).

PECO-30

PECO comments on Section 5.9.4.5(7) that

> "The meteorological sampling scheme used in CRAC is mentioned as a source of uncertainty. CRAC2, which was used in SARA, was specifically developed to reduce this uncertainty."

CRAC, as applied to Limerick, used a sample of 91 (out of an available and representative set of 8760) weather condition sequences, while CRAC2 draws a sample of 116 from the available 8760 sequences by sorting into 29 weighted bins according to relative risk importance. The staff is studying means by which the CRAC2 algorithm may be improved, particularly with respect to sampling of rain intensity. Following this study, the staff may adopt CRAC2 with or without modifications for licensing reviews. The much simpler CRAC sampling scheme is more capable of human verification and, as an interim measure, the staff has chosen the less efficient sampling of CRAC as preferable to the possible methodological uncertainty in CRAC2.

PECO-31

PECO comments on Figures 5.4n, o, p, q, and r that

> "The uncertainty bounds, contradict the text on page 5-54, which states that the risk uncertainty bounds could be well over a factor of 10, but not as large as a factor of 100. Within these uncertainty bounds, however, the uncertainties associated with the probability-integrated values of consequences (the risks) are likely to be less.... No explanation is provided of what the uncertainty bounds represent. They appear to be an arbitrary factor of 100 in all cases. It is expected that the point estimate represents something greater than a 50% confidence level and may be greater than the 90% confidence level in some cases. It is believed that the weight of evidence supports a realistic estimate of risk considerably lower than the DES values and that the DES point estimates are much nearer the upper estimate than the median."

This comment is correct in noting that the lines drawn through all points on the figures cited spanned a factor of 100, and that this is inconsistent with the sentence quoted from the DES. This has been corrected in the FES. With regard to confidence levels, however, the staff does not have sufficient evidence to establish numerical confidence levels.

PEPO-32

PECO comments on Table 6.1 that the reduction in generating costs of $34 million/unit/year presented and discussed in SEction 6.4.2 underestimates the operating savings attributable to Limerick. As presented in EROL Table E320.1-1 (Revision 15, August 1983), the operational savings should be $188.8 million in 1986 for single unit operation.

Prior discussions in the DES and DES Supplement 1 did consider the savings associated with the nuclear plant as compared to alternative energy sources. Consistent with the Commission's regulations in 10 CFR Part 51.21 and 5.1.23(e), these discussions are no longer included in this document. These discussions specifically assess fossil fuels as alternatives to the proposed Limerick nuclear power unit. Costs associated with replacement power as an element of economic risk of severe accidents, however, are considered in Section 5.9.4.5 inasmuch as it is not a consideration of alternate energy sources for the operation of the Limerick facility, instead assesses the economic loss resulting from the need to replace lost power capability with capacity from fossil units existing at that time.

PECO-33

PECO comments on Appendix H that the source terms used by the staff introduce bias into the DES risk assessment, and that the impact of this bias should be assessed.

Several of the source terms have been revised, using less simplistic plant thermal-hydraulic response than used in the DES. Furthermore, the PECO statement, "...source terms used in the staff analysis cannot be much higher in the maximum, but could be substantially lower," is not necessarily an acknowledgement that the source terms are conservative, but is an apparent reflection of the fact that for some isotopes in some release categories, the estimated release may be nearly half, or more, of the core inventory. In such a case, the greatest conceivable release cannot be "much higher." The impact of "substantially lower" source terms would be a lower risk; this lower risk would be represented in the lower ends of the uncertainty bounds discussed in Section 5.9.4.5(7). The staff, however, does not have sufficient information to form a judgment of the level of conservatism associated with the physical/chemical characteristics of the process of fission product release from fuel and attenuation in the various compartments of the Limerick reactor facilities during specific accident sequences. Such information is anticipated as a result of a 1984 review of the subject by the American Physical Society.

PECO-34

PECO comments on Appendix H that more is known about source terms now than at the time of the Reactor Safety Study, but that the staff's assumptions have become more conservative and, therefore, less realistic. It is again repeated that some Limerick source terms are higher than in any past staff analysis.

The staff agrees that more is known about the various phenomena associated with fission product release than was known at the time the RSS was written. The NRC's Office of Nuclear Regulatory Research is currently engaged in a large program to gain a better understanding of these phenomena and to better define the fission product source term. Nevertheless, it is the staff's position that the peer review of these new methods and analyses is not complete and, for the Limerick DES and FES, the methodology of the RSS should be used. (See also response to PECO 16.)

Some of the LGS-DES release categories with larger source terms have been revised downward on the basis of accident thermal-hydraulic considerations. Some of the remaining differences in source terms between this environmental statement and prior BWR environmental statement source terms are due to containment design differences between the Limerick reactors and the base case Peach Bottom reactors which have been used as a surrogate BWR in prior environmental statements.

PECO-35

PECO comments on Appendix H that it is extremely conservative to use a DF of one for a saturated pool. The applicability of a DF of greater than one for a saturated pool has been well established by experiment.

The experiments referred to in some of the references cited have not, in the staff's judgment, definitively established a credible range of DF for the saturated pools. Some of the experiements are not well characterized and others have results too preliminary, in the staff's opinion, to justify usage of an increased DF value in the present modeling. In particular, the staff has concluded that several important parameters are not properly accounted for. The staff, therefore, uses the RSS methodology with a DF of one for saturated pools. This subject is also under review by the American Physical Society as part of its source term considerations. (See answer to PECO-33 also.)

PECO-36

PECO comments on Appendix J that the DES assumptions for emergency response modeling are a limited set of the possible responses. SARA considered a more comprehensive set. (See response to PECO-20.)

PECO-37

PECO comments on Appendix N that comparisons of CRAC and CRAC2 in the international benchmark exercises produced results that are quite close. However, the meteorological sampling scheme use in CRAC leads to much greater uncertainties than in CRAC2; see Figure 9-17 of the PRA Procedures Guide. (See response to PECO-30.)

PECO-38

PECO comments on Appendix N that they have two concerns with the calculation of core inventory. The first is that the use of 105% power is inconsistent with the application to a probabilistic analysis. A power level of 105% is strictly a design basis assumption and is not a best estimate of the actual power level for Limerick. Secondly, the DES used an inventory developed for a PWR by a code (ORIGEN) which was designed for another purpose. The LGS-PRA utilized the code RADCINDER for a BWR core. (See response to Question E.01(b) page Q-126, Vol. 1 of the LGS-PRA.)

As explained more fully in the response to PECO-6, 7, the staff's use of 105% of licensed power is not strictly a design basis assumption. It is not unusual for the central portions of a BWR core to operate at over 105% of core-average power density, while the outer portions operate at much lower power densities. The assumption of 105% of licensed power is a 5% over-estimate for the krypton isotopes, but these contribute little to offsite risk in comparison to the non-gaseous fission products having half-lives of the same magnitude as the time over which offsite doses are computed. For these latter isotopes, the assumption is quite reasonable, rather than being arbitrarily conservative as implied by PECO.

The fission product distribution used by the staff was delibrately chosen to be used for both BWR and PWR core inventories. The division of fissions among the several fissile species present in core is somewhat different between BWRs and PWRs, and the fission yields of their fission products are also somewhat different. In both reactor types, however, fissions by ^{235}U and ^{239}Pu dominate, while the differences in fission yields are most important among the lower-mass fission products. As a result, the risk potentials of the fission products of both reactor types are virtually identical. As discussed in the response to PECO-6, 7, the most significant differences between BWR and PWR inventories, and between the CINDER and ORIGEN algorithms (and the many variations derived from them), lies in neutron captures by the fission products and other non-fissile core materials. These differences, however, are so dependent upon variations in power history and fuel management that any differences in the codes used to calculate the inventories are comparatively unimportant. In summary, the staff sees no advantage in using the inventory calculated by the applicant rather than that derived from WASH-1400.

PECO-39

PECO comments on Appendix N that "the staff criticizes the SARA because there are "too many variations in the optimistic direction for nonsevere earthquake conditions," as one of the factors leading to suspicions that "the upper estimates of the overall CCDFs in the EROL are biased." However, optimistic sensitivity studies in SARA were used to fix the lower estimate and had no effect on the upper estimate."

As also noted in the response to PECO-40, variations in the optimistic direction do not affect the upper portions of CCDFs. The full sentence from which this comment extracted its quote is clear in stating that it is the dearth of pessimistic variations and not the abundance of optimistic variations which leads the staff to disagree with the upper estimates of the overall CCDFs in the ER-OL.

PECO-40

PECO comments on Appendix N that

> "The staff criticizes the SARA analysis for not varying source terms to encompass some of the high values of the release fractions used in the staff analyses."

It was the staff's intent to critique the SARA analysis for combining source terms for individual accident sequences for consequence analysis in such a way that the resulting release categories did not adequately represent the full range of source terms of the individual sequences. This intent is clear in the context of the openning paragraph of Appendix N.

PECO-41

PECO comments on Appendix N that

> "The staff criticizes the SARA because there are "too many variations in the optimistic direction for nonsevere earthquake conditions," as one of the factors leading to suspicions that "the upper estimates of the overall CCDFs in the EROL are biased." However, optimistic sensitivity studies in SARA were used to fix the lower estimate and had no effect on the upper estimate."

PECO also comments that the staff criticizes the SARA analysis for not varying source terms to encompass some of the high values of the release fractions used in the staff analyses. However, as noted in the foregoing discussion of the DES source terms, we believe that the DES source terms are highly conservative. We also believe that the largest source term in SARA, VRH2O, is conservative because radionuclide retention in the primary coolant system and reactor enclosure was neglected. Therefore, we consider that, if criticism is to be leveled at the SARA and EROL soruce terms, it should be because these source terms are too high rather than too low."

The first part of this comment is not a valid argument in support of the applicant's sensitivity studies. The upper portion of any CCDF is totally determined by permutations of accidents and environmental conditions that are the least favorable. The fact that these portions of CCDFs did not change due to variations affecting the remainder of the curves is not an observation of evidence in favor of the adequacy of the applicant's studies.

As discussed in other responses (see PECO-8, PECO-14, 15, and 16), improvements in the thermal hydraulic modelling of most severe accidents has led to reductions in four of the staff's source terms.

PIC - 1, 2

The Council questions the realisms of the models of evacuation, and notes that the Limerick Emergency Preparedness Plan has not yet been completed.

A detailed discussion of the evacuation model appears in Appendix J. The assumed radial evacuation is intended to approximate relative motion between evacuees and the plume, rather than to realistically model actual motion across the terrain. The CRAC weather model contains only radial motion of the dispersing plume; i.e., it is assumed that the wind direction remains unchanged throughout the entire period of plume transport. Plumes from real emissions would change direction with changing wind directions, just as evacuees would change direction of retreat with the course of the road being travelled.

Also see section 5.9.4.4(3) for further information on the Emergency Preparedness Plan.

EPA-1

The EPA comments that the consensus at EPA is that NRC looked at the risks associated with the plant itself, but not with the range of events that can be expected to occur offsite. An example is the transportation of fuel both to and from the facility. Even though this subject has been dealt with generically in another publication, events for this site and its surroundings should be thoroughly analyzed. Perhaps this could be properly dealt with through a comparison with nonnuclear facilities for sheer numbers of accidents, and then working out comparative analysis for the gravity of events using parameters related to radioactive materials. In addition, the AMA carried out a comparative study in an attempt to qualify the risks from air pollution from alternate means of power generation. NRC may find this useful.

The concerns raised by this comment have been addressed in "Health Effects Attributable to Coal and Nuclear Fuel Cycle Alternatives," NUREG-0332, September 1977. Application of this generic study to specific plants has, since 1979, appeared in environmental statements only at the construction permit stage. Since the Limerick construction permit FES was published in 1973, it contained no mention of this generic study.

In response to this comment, a comparison of the fuel-cycle risks of coal and nuclear electrical generation follows. Although gas and oil are currently used in some regions of the U.S., they are not included here because they would not be likely alternatives to coal and nuclear at the Limerick location or, indeed, at most other U.S. regions.

Table 1 provides a quantitative summary of current estimates of excess mortality per year for the entire fuel cycle associated with a nuclear or coal-fired plant generating 0.8 GWyr of electrical energy. The 0.8 GWyr(e) assumption was based on a plant of 1000 MW(e) net capacity operating at an 80% capacity factor, a high-level assumption in the interest of avoiding the underestimation of risks. Health effects, as the term is used here, is intended to mean excess mortality, morbidity (disease and illness), and injury among occupational workers and the general public. ("Excess" is used here to mean effects occurring at a higher-than-normal rate. In the case of death it is used synonymously with premature mortality.)

As seen in Tables 2 and 3 the differential fatality rates in fuel-related transportation accidents for the coal and nuclear options are estimated to yield a net reduction of fatalities from the nuclear option of 1.2 per 800 MWe-yr. As noted in NUREG-0332, pp. 9-10, probably the most reliable estimates of deaths related to the coal fuel cycle are those associated with transportation accidents. Since a 1000 MWe coal-fired plant consumes about 3 million tons of coal per year, there are many thousands of rail shipments per year of coal from mines to electric generating plants. These generating plants consume about 60 percent of U.S. coal production. It is estimated that about one out of every ten trains in the United States is transporting coal for power generation.* These trains are estimated to travel an average distance of 300 miles from mines to plant.** Accordingly, the statistical data on accidental deaths to the general public per ton-mile, or per unit-train mile, provide a fairly reliable statistical basis for estimating fatalities from coal transportation. The frequency of shipments of nuclear fuel are not nearly so great since it takes roughly one ton of nuclear fuel to generate the same quantity of electrical energy as 15,000 tons of coal fuel. Thus, the uncertainty bands for accident-related fatalities of nuclear fuel shipments are not so narrow as those for coal transportation. However, the much lower number of transportation accidents resulting from the greatly reduced number of nuclear fuel shipments means that the greater uncertainty attaining to fatalities from nuclear transport accidents is of negligible significance in a comparative analysis. Note that, according to the risk estimates of Tables 1 and 3, the estimated excess mortality of 1.2 deaths per plant-year resulting from coal transportation <u>alone</u> exceeds the mean estimate of 1.0 deaths per plant-year for the <u>entire</u> nuclear fuel cycle, assuming an all-nuclear supply of electricity as inputs to the nuclear fuel cycle, notably for uranium enrichment.

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*Sagan, Leonard A., "Health Costs Associated with the Mining, Transport and Combustion of Coal in the Steam-Electric Industry," <u>Nature</u>, Vol. 250 (July 12, 1974), pp. 107-111.

**"Energy and the Environment," Council on Environmental Quality (August 1973), p. 43.

Whereas accidental risk to the public from coal transportation is largely a matter of prompt fatalities, there is virtually zero accidental risk of prompt fatalities to the public from pollution pathways or other untoward events

associated with coal-fired generation of electricity. The estimates of 3 to 100 excess fatalities to the public shown in Table 2 are, therefore, almost totally due to the latent, or delayed, deaths associated with chronic air pollution from burning coal to generate electricity. By way of comparison, the geometric mean of 17 excess fatalities is several times greater than the estimated excess fatalities to occupational workers engaged in resource recovery (mining, drilling, etc.), and several hundred times larger than the combined excess fatalities from accidents and disease resulting from power generating using nuclear fuel (see Table 3). Some sizeable fraction of the nuclear accidental fatalities and all of the disease fatalities to the public are in the form of latent cancer fatalities that generally occur about 20-40 years after initial radiation exposure. The remainder of the excess fatalities from nuclear accidents generally occur within the first year of exposure.

The offsite excess fatality estimates of Tables 2 and 3 for coal and nuclear power generation are, to an important degree, population dependent. The generic assumption underlying these estimates was that 3.8 million persons reside within a 50-mile radius of these plants. Doubling this population, all other things being equal, could be expected to roughly double the fatality estimates. Other adjustments need to be made in these tables to accommodate technological change. The data sources on which these tables were based are from 7 to 10 years old. New advances and applications in SO_2 scrubber technology and other forms of pollution control could be expected to reduce substantially the fatality estimates of coal-fired power generation in Table 2. Likewise, there have been many advances in understanding of severe accident risk and methods of risk reduction for nuclear power plants over the same period and more such advances can be expected as a result of NRC's Severe Accident Research Program and operating reactor data and other research conducted in the United States and abroad.

Environmental consequences of nuclear accidents have large uncertainties resulting from the factors discussed in Section 5.9.4.5(7). Similar magnitudes of uncertainties apply to public fatality estimates relating to chronic pollution from the use of coal to generate electricity. Aside from uncertainty over changes in technology and the regulations governing pollution control, there are numerous other sources that contribute to large uncertainties in such risk estimates.*

As described in the literature, the uncertainties of estimating public fatalities from pollutant sources in the use of coal are due to information gaps and conceptual or computational deficiencies in such areas as selection of dose-response

*See, for example,

Holland, W. W.; Bennett, A. E.; Cameron, I. R.; et al., "Health Effects of Particulate Air Pollution: Reappraising the Evidence," American Journal of Epidemiology, Vol. 110, No. 5 (October 1979), pp. 533-651.

Bolten, J. G.; Morrison, P. F.; and Solomon, K. A. "Risk-Cost Assessment Methodology for Toxic Pollutants from Fossil Fuel Power Plants," Rand Corporation Report R-2993-EPRI, June 1983.

models; errors resulting from extrapolating from toxicological effects observable only at the high dose range to estimated effects at low doses; inadequacies of pharmacokinetic data and related assumptions; poor data and modeling of pollutant transport and chemical conversions important to "administered" population doses; variable tumorigenic response between animals and humans, especially sensitive subgroups; population dynamics over time within the region of pollution effects; and confounding factors involving synergesis with other sources of pollution or causes of ailments.

A plant/site-specific analysis of the comparative risks of alternate means of electricity generation would require a costly level of effort far out of proportion to the gain in uncertainty reduction relative to generic analyses of such risks. While regional variabilities in causal factors affecting these uncertainties are considerable, these variabilities can be expected to be within the "noise level" of uncertainties (orders of magnitude) that accompany estimates of both coal and nuclear risks.

There is nothing in the NRC analysis outlined above to suggest that either the use of coal or nuclear fuels to generate electricity at the Limerick site should not, from the standpoint of scientific analysis, be a socially acceptable option in comparison to the background risks of other kinds routinely accepted by the regional population. This statement recognizes that there are important differences in perceptions of the acceptability of risks and risk-cost-benefit assessments.*

EPA-2

EPA questions the use of mathematical models in cases in which either design error or human actions contributed to the cause of an accident.

Although the Limerick PRA was relatively circumspect when assessing risks, there were some areas outside the scope of the Limerick PRA. The EPA accurately observed the exclusion of data that would reflect errors caused uniquely during equipment manufacturing, construction and installation. These areas and others (e.g., sabotage, some errors of commission) were beyond the scope of the Limerick PRA, which is typical of the current scope of PRAs. However, the NRC assures public safety against sabotage and possible errors during manufacturing, construction, and installation through its reviews of the plant physical security and safeguards programs, and of the vendors' and applicants'/licensees' quality assurance programs, respectively.

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*See, for instance,

Spangler, Miller B., "Risks and Psychic Costs of Alternative Energy Sources for Generating Electricity," The Energy Journal, Vol. 2, No. 1, 37-59 (January 1981).

Spangler, Miller B., "The Role of Interdisciplinary Analysis in Bridging the Gap Between the Technical and Human Sides of Risk Assessment," Risk Analysis: An International Journal, Vol. 2, No. 2, 101-144 (1982).

Covello, Vincent T., et al., The Analysis of Actual Versus Perceived Risks (New York: Plenum Press, 1983).

EPA-3

This comment on Appendix H asks if accidents of different consequences and probabilities have been combined within the same release category, and if so, has due account been taken of the effects low consequence events may have in rendering high consequence events more probable.

The analyses do include additional probabilities of the failure of additional safety features which might result from the initiating failure. To the greatest extent possible, release categories are defined by combining events which have very similar computed releases. In practice, the process of combining a large number of accident scenarios into a smaller number of release categories does introduce some conservative overestimation of risk, but errors of the sort identified in this comment are intentionally avoided.

Based on Appendix H, Table 5.11c lists 27 types of potential release scenarios involving defeat of one or more of the safety systems, and Table 5.11d lists the probabilities associated with these scenarios. The scenarios for which the probabilities are not extremely low (10^{-9} per reactor-year or less) are individually analyzed and estimates of their respective conditional mean (meteorology-averaged) consequences are shown in Table K.1. Although not explicitly pointed out in the DES or FES, inspection of Tables 5.11c and 5.11d shows that the scenarios associated with relatively high probabilities of occurrence are associated with relatively smaller quantities of radionuclides in their releases resulting in relatively low estimates of conditional mean consequences.

EPA-4

In further expanding upon its earlier comments (EPA-2 and -3) on Appendix H, EPA asks:

(a) Are the ranges of plant monitors sufficient to encompass severe accidents as well as normal operating conditions?

(b) Does the listing of accident sequences in Appendix H represent analysis of the plant design, or only include combinations of failures that have already been experienced singly.

In response:

(a) Instruments of possible use in responding to accident conditions are required to be designed to survive accident conditions and to perform correct measurements under these conditions independent of operational limits.

(b) The accident sequences considered are so large in number that it is necessary that they be grouped into the small number of surrogate damage states and release pathways appearing in Appendix H. The sequences are developed from analysis of the plant design, but their assigned probabilities contain information obtained from operational experience.

EPA-5

This comment states that consequences arising during exceptionally unfavorable weather conditions have been inadequately treated, and suggests that extreme condition doses should be limited by regulations.

The first part of the comment misinterprets the statement in the cited paragraph. Only the last two sentences in the paragraph relate to the offsite dispersion of radioactive materials; and only the last sentence indicates that rain would influence the offsite dispersion. However, the last sentence in the paragraph does not at all imply that wet weather would minimize the impacts of radionuclide releases. Influence of rain on the impacts is quite complicated and is taken into account in the staff and applicant plume dispersion and consequence calculations. The meteorological sampling scheme used in the staff analysis is intended to take into account the effect of wet, dry, windy, and other meteorological conditions and to incorporate considerations of unfavorable weather conditions.

The second part of this comment suggests that the FES should contain a discussion of plans either to establish regulations governing maximum accidental doses, or to expand the interpretation of existing regulations toward the same end, without consideration of the probability that such doses might ever be received. At present, such a discussion would be beyond the scope of the FES. The subject of accident consequences is discussed, however, at length in the Commission's June 13, 1980 Statement of Interim Policy on Nuclear Power Plant Accident Considerations Under the National Environmental Policy Act of 1969 (45 FR 40101), as summarized in Section 1.2 of the FES.

EPA-6

This comment notes that waterside corrosion is discussed in the SER, but not the DES, and suggests that the status of regulatory efforts to minimize such corrosion be included in the FES. In addition, the comment questions whether or not waterside corrosion in a core could exacerbate minor transients.

To date, five BWR plants have experienced waterside corrosion failures. All the failed rods contained gadolinia. General Electric characterized these failures as crud induced localized corrosion, which was attributed simultaneously to a combination of material and operational factors. GE has stated that a means has been developed to assure that these factors cannot occur simultaneously, thereby effectively controlling the cause of the failure. GE has also provided recommendations to the affected licensees and applicants to assure this. Based on the GE findings and recommendations, the NRC staff has concluded that reasonable assurance of controlling waterside corrosion failures has been provided and that the problem of waterside corrosion is satisfactorily resolved.

Furthermore, waterside corrosion failure is a gradual process. Therefore, unlike other cases (for example, rod overpressurization), waterside corrosion cannot exacerbate a minor event such as unexpected shutdown of cooling systems with associated pressure loss or rise in the reactor vessel.

EPA-7

EPA comments on Section 6 relating to "the benefits to be realized from operation of two units. Presumably these benefits will accrue to the consumer, although this is not stated in the text, and they amount to $34 million (1985 dollars). How is this figure reconciled with PECO's recent statement that they will petition the Pennsylvania Utility Commission in the Spring of '84 for a 20% rate raise to cover costs associated with Unit one and for another rate raise of 20% in '85 to cover the cost of Unit 2? Translated into current dollars, the initial request will amount to $477 million cost to the consumers. Perhaps NRC should carry out an analysis of conventionally fueled power production so that the benefit claimed will be put into a better comparative perspective.

In addition, the decommissioning costs appear to be underestimated, even though set in a large range. Following the logic associated with the escalating costs of construction, it would seem that decommissioning should following the same path."

Prior discussions in the DES and DES Supplement 1 did consider the savings associated with the nuclear plant as compared to alternative energy sources. Consistent with the Commission's regulations in 10 CFR Parts 51.21 and 51.23(e), these discussions are no longer included in this document. These discussions specifically assess fossil fuels as alternatives to the proposed Limerick nuclear power unit. Costs associated with replacement power as an element of economic risk of severe accidents, however, are considered in Section 5.9.4.5 inasmuch as it is not a consideration of alternate energy sources for the operation of the Limerick facility, instead assesses the economic loss resulting from the need to replace lost power capability with capacity from fossil units existing at that time.

The staff also notes that as stated in Section 5.11, the NRC is currently undergoing a rulemaking proceeding that will develop a more explicit overall policy for decommissioning commercial reactors. Until this proceeding is completed, the staff relies on NUREG-0586, "Draft Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities" for estimates of costs for various decommissioning alternatives. A comparison of the NUREG's estimated costs with the costs provided by the applicant indicates that costs tending toward the upper portion of $10 million - $100 million range estimated by the applicant are more likely to be incurred than costs tending toward the lower end. The staff has no reason to believe that decommissioning costs will appreciably exceed the range provided by applicant.

EPA-8

EPA notes that, as stated in Section 5.9.4.4(3) of the DES Supplement, the emergency preparedness plans are incomplete but in preparation. EPA apparently feels that these plans should be evaluated and the results presented in full detail in the environmental statements.

The NRC staff agrees with part of EPA's further statement that a major objective of the emergency preparedness plans "...is to assure the safety in times of accidents." The staff notes however that the discussion of emergency planning to which EPA refers in the DES supplement is for the purpose of introducing information to support the environmental assessment of severe accidents. As noted in the DES Supplement, the NRC staff will determine the adequacy of the applicant's emergency response plans with respect to the standards listed in 10 CFR Part 50, NUREG-0654/FEMA-REP-1 and will report the findings in a supplement to the safety evaluation report.

EPA-9

An objection is raised to a statement that radiation has been studied more exhaustively than other environmental contaminants. This statement has been revised.

EPA-10

This comment disputes the use of mathematics in treating the health effects of radiation, and suggests that specific authorities be relied upon so that non-mathematical aspects, such as public awareness, can be afforded weight.

The cited paragraph does contain reference to a specific document, namely: NAS BEIR III Report (1980) which is based on an evaluation of a large body of scientific information on the subject of health effects of radiation.

The NRC staff has not assumed design "to be primarily a problem in mathematics." Rather, safety questions related to nuclear power plant design, construction, and operation are raised and answered using traditional conservative deterministic engineering techniques, and have relied on a defense-in-depth approach to design and operation. Probabilistic risk analyses involving sophisticated mathematical modeling techniques generate many insights that only help in making additional safety judgments for the plants that may or may not have passed the staff review using stringent regulatory guidelines based on deterministic principles.

Attention is given to non-design factors such as human factors during the staff review in both the deterministic and probabilistic techniques.

Information provided in Draft and Final Environmental Statements, information distributed to the public as part of plans for emergency preparedness, information brought to light during the public hearing process for licensing, and information provided in other regulatory channels such as Federal Register Notices do serve in raising public awareness.

DOI-1

Interior commented that it would be an important part of the analysis to evaluate the amount of time during which interdiction of the aquatic food pathway would require shutting off water supply intakes on the Schuylkill River in the event of severe accidents.

The last paragraph of Section 5.9.4.5.(3), page 5-33, discusses fallout onto open water bodies, drawing an analogy from a study of severe accidents at the Fermi Unit 2 reactor on Lake Erie to conclude that the accident consequences and risks from the liquid pathway at Limerick would be small compared to the consequences and risks from fallout on land. The text has been expanded to more fully explain the analogy, and it also discusses another set of calculations of potential nuclide concentrations in New York City water from postulated

Indian Point accidents. The relative risk contribution from the liquid pathway for this case was also shown to be small. Finally, the staff is unable to identify any conditions at the Limerick plant and environs that would indicate a different conclusion for the liquid pathway there.

DOI-2

Interior commented that

> "Potential adverse effects to fish and wildlife resources from exposure to radioactive materials are not considered. The Fish and Wildlife Service is supporting efforts by the Pennsylvania Fish Commission to restore anadromous fish runs to the Schuylkill River. The Schuylkill River also serves as a major flyway for raptors and waterfowl from central New York State and the Great Lakes. Effects of potential contamination on these fish and wildlife resources should also be considered."

The NRC staff is aware of the anadromous fish restoration efforts currently underway for the Schuylkill River (see FES Section 4.3.4.2.5, last paragraph). Evaluation of the consequences of a severe reactor accident resulting in radionuclide releases to groundwater that eventually seeps into the river, the type of accident that would result in the greatest radionuclide concentrations, is contained in FES Section 5.9.4.5 (5).

As a result of the slow groundwater movement and ion exchange properties at the geologic medium, only a very small fraction (0.4%) of the original inventory of strontium-90 (the cesium-137 contribution is insignificant) would seep into the river during any one year following the postulated accident. The maximum strontium-90 inflow would occur approximately 150 years after the penetration of the basemat assuming that no mitigation measures are undertaken. The calculated dose due to immersion would be in the order of a few millirads per month even during a 100-year low river flow. This dose is far below the lethal limit for fish eggs which is the most radiosensitive life stage of fishes (NRC Liquid Pathway Generic Study (LPGS), Section 5.1.1).

In addition, mitigation measures could be undertaken after an accident to assure that the total release of radioactivity to the hydrosphere would be far below that assumed in the liquid pathway analysis (FES Section 5.9.4.5 (5)).

Radionuclide contamination of the Schuylkill River fishery resources via the groundwater pathway is not expected, therefore, due to a combination of the radionuclide holdup capability of the site hydrogeology and the mitigation measures available to interdict any escaping radioactivity.

The LPGS (page 5-17) declares that the effects to waterfowl population of an accidental release to the liquid pathway would be expected to be minimal. The Limerick study shows that radionuclide transport is small in comparison to the LPGS. Therefore, the staff finds that the conclusion of minimal impacts in the LPGS regarding impact to waterfowl are also applicable to Limerick.

Table 1 Summary of current energy source excess mortality per year of 0.8 GWyr(e)

Fuel cycle	Occupational		General public		Total
	Accident	Disease	Accident	Disease	
Nuclear (U.S. population)					
All nuclear	0.22[a]	0.14[b]	0.05[c]	0.18-1.3[b]	0.59-1.7(1.0)[d]
With 100% of electricity used in the fuel cycle produced by coal power	0.24-0.25[a,e]	0.14-0.46[b,a]	0.10[c,g]	0.77-6.3[h]	1.2-6.8(2.9)
Coal (regional population)	0.35-0.65[e]	0-7[f]	1.2[g]	13-100[h]	15-120(42)
Ratio of coal to nuclear (range): (geometric means)	42 (all nuclear) 14 (with coal power)[i]				

[a]Primarily fatal nonradiological accidents, such as falls or explosions.

[b]Primarily fatal radiogenic cancers and leukemias from normal operations at mines, mills, power plants and reprocessing plants.

[c]Primarily fatal transportation accidents (Table S-4, 10 CFR Part 51) and serious nuclear accidents.

[d]Values in parentheses are the geometric means of the ranges ($\sqrt{ab}$).

[e]Primarily fatal mining accidents, such as cave-ins, fires and explosions.

[f]Primarily coal workers pneumoconiosis (CWP) and related respiratory diseases leading to respiratory failure.

[g]Primarily members of the general public killed at rail crossings by coal trains.

[h]Primarily respiratory failure among the sick and elderly from combustion products from power plants, but includes deaths from waste-coal bank fires.

[i]With 100% of all electricity consumed by the nuclear fuel cycle produced by coal power; amounts to 45 MW(e)/0.8 GWyr(e).

Table 2 Excess mortality per 0.8 GWyr(e) Nuclear[a]

	Occupational		General public		
Fuel-cycle component	Accident[b]	Disease[c,d,e]	Accident[e,f]	Disease[g]	Total
Resource recovery (mining, drilling etc.)	0.2	0.038	~0	0.085	
Processing[h]	0.005[i]	0.042	j	0.026-1.18	
Power generation	0.01	0.061	0.04	0.016-0.02	
Fuel storage	j	~0	j	~0	
Transportation	~0	~0	0.01[k]	~0	
Reprocessing	j	0.003	j	0.054-0.062	
Waste management	j	~0	j	0.001	
Total	0.22	0.14	0.05	0.18-1.3	0.59-1.7

[a]Breakdown of Table 1.

[b]Hamilton, L. D., "The Health and Environmental Effects of Electricity Generation," Brookhaven National Laboratory (July 1974).

[c]USNRC, Final Generic Environmental Statement on the Use of Recycle Plutonium in Mixed Oxide Fuel in Light Water Cooled Reactors, NUREG-0002 (August 1976).

[d]10 CFR Part 51, Table S-3.

[e]10 CFR Part 51, Table S-4.

[f]USNRC, Reactor Safety Study, WASH-1400 (NUREG-75-014) (October 1975).

[g]Long-term effects from ^{222}Rn releases from mills and tailings piles account for all but 0.001 health effects.

[h]Includes milling, uranium hexafluoride production, uranium enrichment and fuel fabrication.

[i]Corrected for factor of 10 error based on referenced value (Report WASH-1250).

[j]The effects associated with these activities are not known at this time. Although such effects are generally believed to be small, they would increase the total in the column.

[k]Contemporary risk estimates in this area may be conservative. Murray, Raymond L., Understanding Radioactive Waste (Columbus, Ohio: Battelle Press, 1982), pp. 61-64.

Table 3 Excess mortality per 0.8 GWyr(e)-Coal[a]

	Occupational		General public		
Fuel-cycle component	Accident	Disease	Accident	Disease	Total
Resource recovery (mining, drilling, etc.)	0.3-0.6	0-7	b	b	
Processing	0.04	b	b	10	
Power generation	0.01	b	b	3-100	
Fuel storage	b	b	b	b	
Transportation	b	b	1.2	b	
Waste management	b	b	b	b	
Total	0.35-0.65	0-7	1.2	13-110	15-120

[a]Breakdown of Table 1. See also, Hamilton (1974).

[b]The effects associated with these activities are not known at this time. Although such effects are generally believed to be small, they would increase the total in the column.

APPENDIX A
COMMENTS

PART I

Comments on the Draft Environmental Statement, NUREG-0974, issued in June 1974

Part II

Comments on Supplement No. 1 to the Draft Environmental Statement, NUREG-0974, issued in December 1983

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COMMENTS ON THE DRAFT ENVIRONMENTAL STATEMENT

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PART II
Supplement No. 1 to the Draft Environmental Statement

CITY OF PHILADELPHIA

LAW DEPARTMENT
15th Floor, Municipal Services Building
Philadelphia, Pa. 19107

August 12, 1983

Secretary
United States
Nuclear Regulatory Commission
Washington, D. C. 20555

Re: Limerick Generating Station, Units 1 and 2, Docket Nos. 50-352 and 50-353, Draft Environmental Statement

Dear Secretary:

Enclosed herewith please find an original and three copies of the City of Philadelphia's Comments relating to the above-listed document.

Sincerely,

Martha W. Bush

Martha W. Bush
Deputy City Solicitor

C002
1/1

COMMENTS OF THE CITY OF PHILADELPHIA
RE: DRAFT ENVIRONMENTAL STATEMENT
RELATING TO THE OPERATION OF
LIMERICK GENERATING STATION,
UNITS 1 AND 2, DOCKET NOS.
50-352 AND 50-353

Phil-1 The City of Philadelphia hereby notifies the Commission of its comments on the above-listed document. At this time, pending submission of the supplement to the Draft Environmental Statement ("DES"), the City has no comments on the substance of the DES. However, the City believes that conclusions as to environmental impacts of Unit No. 2's operation are premature and issuance of such conclusions at this time is a violation of the National Environmental Policy Act of 1969 (NEPA).

Unit No. 2 is not projected by the Applicant to be completed until late 1988. Because of the long period of time between issuance of the DES at issue (June, 1983) and potential operation of the plant (October, 1988), environmental impacts cannot be accurately or reasonably assessed, e.g., existing water and air quality conditions. Furthermore, many of the environmental standards that are applied in a DES are evolving standards, *e.g.*, clean air and water standards and acceptable low level radiation levels. To approve Unit No. 2's operation long before its expected operation deprives the public of legally enacted environmental requirements concurrent with the Unit's initial operation.

For these reasons, the City of Philadelphia respectfully urges the Commission to hold in abeyance any conclusions as to the environmental impacts of Unit No. 2's operation until an environmental analysis and review can be made consistent with environmental conditions and standards at operation.

Respectfully submitted,

Martha W. Bush

MARTHA W. BUSH
Deputy City Solicitor

2

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
Post Office Box 2063
Harrisburg, Pennsylvania 17120
October 4, 1983

(717) 783-1566

PA

A. Schwencer, Chief
Licensing Branch Number 2
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

50-352
50-353

Dear Mr. Schwencer:

We have reviewed the Draft Environmental Statement, Limerick Generating Station, Units 1 and 2, Montgomery County, Pennsylvania.

The information and findings of the Draft Environmental Statement concerning water supply are consistent with the findings of the Delaware River Basin Commission's Docket No. D69-210 CP (final) for the project and the Pennsylvania Department of Environmental Resources "Environmental Assessment Report and Findings on the Point Pleasant Water Supply Project", August 1982.

PDER-1 With respect to radiation issues, the report should address the matter of low level radioactive waste storage and disposal. This is particularly important in light of the current and near term shortfall of disposal site capacity.

PDER-2 We note that the NRC staff analysis of the impact of an accident on populated areas was not included in the document. We look forward to its issuance as a supplement to this Environmental Statement.

We found nothing unusual in the other sections dealing with radiation issues. The information offered is generally consistent with that offered in environmental statements for similar facilities.

The Limerick plant operation is outside of the coastal zone and will not deleteriously impact any Coastal Zone Management policies.

We agree that the three auxiliary boilers, any two of which are operating at one time, and the emergency diesel generators will have no significant impact on air quality in the vicinity of the plant.

C002
1/1

We have also generated a number of specific comments dealing with the text of this report. They are included in the attachment.

Thank you for the opportunity to review this project.

Sincerely,

Richard J. Pastor

RICHARD J. PASTOR, Director
Office of Policy

Attachment

Specific Textual Comments of the Department of Environmental Resources on the Draft Environmental Statement on the Operation of the Limerick Generating Station, Units 1 and 2

PDER-3 1. On page 4-20, third paragraph - the Blue Marsh flood control storage is 32,390 acre-feet, not 22,850 acre-feet.

PDER-4 2. Page 4-20, fourth paragraph - the streamflow gauge being sited should be identified as U.S. Gauge 01472000, the Schuylkill River at Pottstown.

PDER-5 3. The review document should indicate in an appropriate section the fact that the Schuylkill River has been designated a component of the Pennsylvania Scenic River system by Act 333 of November 26, 1978 (P.L. 1415) cited as the "Schuylkill Scenic River Act".

PDER-6 4. Page 5-1, Section 5.2.2, which concerns land use along transmission lines, should also indicate that railroad right-of-way purchased to accommodate transmission lines should contain an easement which would permit a recreational trail within the transmission right-of-way and preserve access to river frontage on both sides of the river between Cromby and Plymouth Meeting.

DELAWARE RIVER BASIN COMMISSION
P.O. BOX 7360
WEST TRENTON, NEW JERSEY 08628
(609) 883-9500

50-352

GERALD M. HANSLER
EXECUTIVE DIRECTOR

HEADQUARTERS LOCATION
25 STATE POLICE DRIVE
WEST TRENTON, N.J.

July 22, 1983

Dr. Rajender Auluck, P.E.
Project Manager
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Dr. Auluck:

SUBJECT: Draft Environmental Statement Related to the Operation of Limerick Generating Station Units 1 and 2
DRBC File No. D-69-210 CP (Final)

We have received a copy of the subject statement and note that one reference to the Delaware River Basin Commission (DRBC) docket D-69-210 CP appears to have an incorrect interpretation of applicable conditions.

DRBC-1

In the beginning of the first complete paragraph on page 5-14, the statement is made that DRBC has established a mixing zone for discharge of constituents such as residual chlorine and adds that outside of this zone the cooling tower blowdown discharge shall not cause a violation of the water quality standards.

The docket decision for the Limerick project [D-69-210 CP (Final)] did not establish any mixing area for constituents like residual chlorine. The docket does establish a heat dissipation area to accommodate only the thermal characteristic of the discharge and did establish a temporary mixing area for turbidity during construction of the river bank facilities.

All other regulations of the DRBC are applicable as written, including effluent limitations which are applicable prior to mixing with receiving waters.

Sincerely,

G. M. Hansler

Gerald M. Hansler

cc: Philadelphia Electric Company

C004 1/0

August 9, 1983

318 Summit Ave. #3
Brighton, Mass. 02135

Dr. Rajender Auluck, P. E.
Project Manager
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington D. C. 20555

SUBJECT: COMMENT ON NUREG-0974, DRAFT ENVIRONMENTAL IMPACT STATEMENT, PHILADELPHIA ELECTRIC CO., LIMERICK GENERATING STATION, UNITS 1 & 2, Docket No. 50-352, 50-353.

Dear Dr. Auluck,

John F. Doherty, of 318 Summit Ave., Brighton, Massachusetts, comments as below on the DEIS:

COMMENT 1

JFD-1 The DEIS is deficient because it does not contain a worst case analysis of an accident and its effect on the environment, and an estimate of its probability, as required by the National Environmental Policy Act of 1969, §§ 2, et seq., 102. A "worst case" analysis is not beyond the statutory minima of NEPA. (See: Sierra Club v. Sigler, 695 F 2d 957, 5th Cir.: 1983)

COMMENT 2

JFD-2 The DEIS fails to mention other serious cancer and infant mortality impacts on human beings from tailings piles which must be created to provide the fuel for the two Limerick atomic plants. Thus, at page C-6, it states "A single model 1000-MWe LWR operating at an 80% capacity factor for 30 years would be predicted to induce between 3.3 and 5.7 cancer fatalities in 100 years, 5.7 and 17 in 500 years, and 36 and 60 in 1,000 years as a result of releases of radon-222." (This does NOT refer to operation of the plants, it refers to Table C-4; operation of the plant does not create Radon as can be seen from Table D-1)

Thus, the FES should contain additional impacts from the fuel cycle to fuel a 1000 MWe unit which befall humans.

These would be: between 3.5 and 5.7 non-fatal cancers in 100 years, 5.7 to 17 in 500 years and 36 and 60 in 1000 years as a result of release of radon-222, from "stabilized tailings piles." Also, since the amount of fatal birth defects impact is equal to the fatal cancer impact, there would be between 3.5 and 5.7 fatal birth defects in 100 years, 5.7 to 17 in 500 years and 36 and 60 in 1000 years as a result for release of radon-222 from "stabilized talings piles." And, since the fatal birth defects from these piles are believed to be equal to the number of non-fatal birth defects, there would be between 3.5 and 5.7 non-fatal birth defects in 100 years, 5.7 to 17 in 500 years, and 36 to 60 in 1,000 years as a result of release of radon-222, from "stabilized tailings piles." (See: Testimony of Appeal Board Member Gotchy in Allens Creek CP proceedings, Dr. Gotchy was with NRC Staff at that time.)

While it is probably likely a decrease in fatal cancers can be expected over the course of the next 1,000 years, which would decrease this fuel cycle impact, probably this is not true for the fatal birth defects.

The DEIS should be modified such that the FEIS gives fatal and non-fatal total ranges. Non-fatal cancers, fatal birth defects and non-fatal birth defects are significant impacts.

JFD-3 COMMENT 3

The effect of the transmission lines on migratory birds has evidently not been explored or considered.

COMMENT 4

JFD-4 Page D-1 of the DEIS states, "For younger persons, changes in organ mass and metabolic parameters with age after the initial uptake of radioactivity are accounted for." This would seem to indicate there accounting for the sex of the individual. While there are certainly changes with age in adolescense for both sexes, the DEIS should indicate if its assessment of dose takes in contamination of woman at menstruation when breast tissue cells are in rapid multiplication.

Thank you for the opportunity to comment.

I would like to receive a copy of the planned supplement to this DEIS on the probabilistic risk assessment analysis of severe accidents. This is relevant to Comment 1, above.

John F. Doherty

John F. Doherty

limerick ecology action

BOX 761 • POTTSTOWN, PA. 19464 • (215) 326-9122

a member of the environmental coalition on nuclear power

COMMENTS ON NUREG 0974, June 1983

Draft Environmental Statement for
Limerick Generating Station
Units 1 and 2, Dockets 50-352,353

Submitted by Phyllis Zitzer,
President of Limerick Ecology Action
August 12, 1983

C002
0/1

limerick ecology action

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a member of the environmental coalition on nuclear power

"The environmental impacts of postulated plant accidents will be provided in a supplement to this statement." (1)

"The plant specific review of the Limerick probabilistic risk assessment analysis of severe accidents is not complete." (2)

LEA-1 Yet despite this obvious lack of completion of NRC Staff reviews of the Limerick PRA and SARA, the resulting action called for by the NRC Staff in this document is,

"issuance of operating licenses for Limerick Generating Station, Units 1 and 2." (3)

LEA-2 Furthermore, the only discussion of emergency planning impacts is ludicrous. "The Staff believes the only noteworthy potential source of impacts to the public from emergency planning would be associated with the testing of the early notification system." (4) The next sentence discusses noise levels from existing alert systems and concludes that noise impacts will be "infrequent and insignificant". (5)

LEA-3 Most of the rest of this document attempts to justify continued construction and operation of the Point Pleasant water diversion plan for use at Limerick.

For the record, Limerick Ecology Action wishes to bring to your attention the attached letter from the U.S. Fish and Wildlife Service, dated July 20, 1983 that discusses alternatives to the construction of the Point Pleasant water diversion and the Merrill Creek Reservoir.

LEA-4 In view of the conclusion already recommended by the NRC Staff in regards to the issuance of an operating license, members of LEA question whather the NRC intends to objectively review the revised contentions, testimony and litigation yet to be filed in this proceeding by intervenors in this case.

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(1) Abstract iii, DES
(2) Summary & Conclusions viii, DES
(3) Abstract iii, DES
(4) (5) p.5-91, DES

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
One Gateway Center Suite 700
NEWTON CORNER, MASSACHUSETTS 02158

JUL 20 1983

Mr. R. Timothy Weston
Deputy Assistant Secretary
Pennsylvania Department of
Environmental Resources
P.O. Box 1467
Harrisburg, Pennsylvania 17120

Dear Mr. Weston:

This responds to your June 1, 1983, letter to Director Jantzen requesting the Service's comments on three alternatives to supply water to the Limerick Nuclear Generating Station, Chester and Montgomery Counties, Pennsylvania.

Alternative 1 (reduction of Schuylkill River flows/use of Blue Marsh storage).

DRBC Docket No. 69-310 CP placed two restrictions on water withdrawn from the Schuylkill River at Limerick: a) flows at the Pottstown gage must exceed 530 cfs with one unit operating and 560 cfs with two units operating; and b) there must be no withdrawals when water temperatures below Limerick exceed 15°C, except during April, May, and June when the flows as measured at the Pottstown gage exceed 1,791 cfs.

Use of this alternative would not require relaxation of the 530/560 cfs flow restriction established by the DRBC. It would require only that attention be given to identifying and utilizing the potential for storing sufficient makeup water in Blue Marsh Reservoir (see discussion of Blue Marsh under Alternative 2). Given a recurrence of the 1965 drought, approximately 8,000 acre-feet of stored water would be required to meet DRBC's flow restriction of 530 cfs with one unit operating at maximum output. There are 6,000 acre-feet of storage currently in Blue Marsh Reservoir for industrial and municipal use and another 6,600 acre-feet for water quality control downstream. We believe that the Philadelphia Electric Company could operate Unit 1 using the Blue Marsh Reservoir as an interim source of make-up water until environmentally-sound storage facilities could be developed. Initiation of operation of Unit 2 and continued long-term operation of Unit 1 should be contingent upon either expanding existing storage reservoirs or developing new sources of storage in the Schuylkill drainage. In any event, we do not recommend that the required flows of 530 and 560 cfs be reduced in any alternative plan.

We believe that the second restriction could be relaxed without degrading water quality downstream. The restriction was originally designed to protect water quality and fishery resources and appears somewhat conservative in light of results of the 1976 COWAMP Study for the Schuylkill River. For example, the water quality model developed for the study predicted very few violations of State standards for dissolved oxygen in the Philadelphia area at a flow of 290 cfs and a water temperature of 29°C. The study also predicted that water quality would improve in the future as more sewage treatment plants were upgraded. The Department of the Interior's 1968 Water Quality Control Study for Blue Marsh Reservoir made similar observations, indicating that dissolved oxygen levels in the lower Schuylkill River did not drop below 4.0 mg/l until flows were less than 300 cfs. Any proposal or plan to relax the second constraint on withdrawal should be based upon a thorough investigation of the relationship between consumptive withdrawals at Limerick and resultant water quality alterations downstream, particularly those involving water temperature and dissolved oxygen.

<u>Alternative 2</u> (Construction of the Red Creek Reservoir).

In letters dated February 25, 1974, and June 25, 1974, the Department of the Interior recommended the Licensee consider make-up water storage sites in the Schuylkill River Basin. More recently, the Department's October 26, 1982, letter on the draft Environmental Impact Statement for the Merrill Creek Reservoir Project recommended the re-evaluation of storage reservoirs on the Schuylkill River as less environmentally damaging than the Merrill Creek site. During the screening of alternative sites for the Limerick Nuclear Generating Station make-up water source, the Red Creek site was eliminated primarily because of poor water quality and the Blue Marsh site because it would not be completed in time. However, delays in constructing the Limerick Nuclear Generating Station have changed the status of these two sites.

Because of reduced mining effort and the success of reclamation projects upstream of the Red Creek site, water quality in the Schuylkill River has significantly improved in the past six years. The Red Creek site could now withdraw reasonably good quality water from the Schuylkill River with ph in the range of 6-7 units. We now believe that water quality in a reservoir on Red Creek would support a good warmwater fishery. Furthermore, discharges from the reservoir would benefit aquatic organisms in the Schuylkill River during low flow periods. Therefore, the Red Creek site appears well suited for fulfilling the need for additional storage in the Schuylkill River Basin (although perhaps not uniquely so).

The Blue Marsh Reservoir is now completed and operational. The necessary additional make-up water storage capacity for the Limerick Nuclear Generating Station could be made available by raising the pool level in the Blue Marsh Reservoir 6 feet for one unit and 9 feet for two units. This would permanently flood an additional 300 and 450 acres of land, respectively. Either alternative reservoir site on the Schuylkill River would eliminate the need for building the Point Pleasant Diversion project, Bradshaw Reservoir, and possibly the Merrill Creek Reservoir. Sites on the Schuylkill River would benefit water quality by providing additional flows during low water in the river.

<u>Alternative 3</u> [Bradshaw Reservoir/Bradshaw Pump Station (Point Pleasant)].

The Service has advised against constructing the Point Pleasant Diversion project for numerous reasons. Our March 11, 1980, and December 16, 1980, letters to the DRBC identified and discussed at least 12 specific adverse environmental impacts that could result from constructing and operating the Point Pleasant project. Our letters of June 19, 1981, and March 26, July 12, and September 14, 1982, to the Corps of Engineers presented additional reservations about the proposed project. We summarized our concerns again in our letter of October 18, 1982, which recommended denial of the Department of the Army permit for the project. Throughout all of our communication with DRBC and the Corps, we maintained that there were environmentally preferrable alternatives to the Point Pleasant project.

In summary, from a fisheries conservation and management perspective, of the three alternatives that you proposed we would prefer Alternative 2.

If we can be of further assistance, please do not hesitate to ask.

Sincerely yours,

Howard N. Larsen

Regional Director

The Mercury, Pottstown, Pa. — Thursday, August 4, 1983

South Coventry refuses to accept PE evacuation plan

By MIKE CONTOS
Mercury Staff Writer

South Coventry Township officials this week refused to take part in evacuation plans for the nuclear power plant in Limerick and said they would approve no plans until someone other than the township pays for a survey of municipal emergency resources.

The rural Chester County township declined to "fill in the blanks" on a draft plan Philadelphia Electric Company's consultant presented officials Monday. The refusal was the first by any of the 42 municipalities within a 20-mile radius of Limerick involved with the evacuation planning.

"We're not going along with any plans until PE shows us who is going to pay for it," said Richard Whitlock, chairman of the three-member board of supervisors.

Whitlock said Energy Consultants, the firm retained by PE to work with municipalities and school districts to create individual evacuation plans, presented a draft proposal to the township on Monday. The supervisor said the proposal was a simple form given to all municipalities with blank spaces to fill out.

"There are too many gaps in the forms and a lot of unanswered questions," Whitlock said. "We're not going to approve something for them (Energy Consultants) to send to the NRC (Nuclear Regulatory Commission)."

Whitlock said South Coventry was not the only municipality declining to take part in evacuation plans and that many townships and boroughs throughout the nation are holding back until learning clear-cut methods of funding for the preparations.

He cited a recent investigation by the General Accounting Office, Congress' investigative arm, which leveled heavy criticism at the NRC for accepting evacuation plans that were deficient. The investigation said there are no minimum planning standards for evacuations and no follow-up procedures.

In recent months the NRC has encountered difficult emergency planning problems with two reactors near densely populated New York City — Indian Point in Westchester County and Shoreham on Long Island. In the case of Shoreham, Suffolk County authorities have refused to cooperate in setting up evacuation plans, and are jeopardizing the start-up of the plant.

"I object vehemently that under the draft plan residents of South Coventry Township would have to be evacuated to two different locations," Whitlock said. He added the plan called for 90 percent of the 1,644 residents to head west along Route 23 to the Morgantown area, while the rest would be evacuated south along Route 100 into Downingtown.

"If we have to evacuate, there will be no splitting of South Coventry Township," Whitlock said.

All municipalities within a 20-mile range of the Limerick site have been presented draft plans to provide for a mass evacuation of shut-ins, the blind and the disabled, as well as the able-bodied. The municipalities have been asked to research their emergency resources and forward the information to their respective county governments.

The state is ultimately responsible for a master evacuation plan. It is undetermined if an individual plan could be forced onto South Coventry without the approval of the local officials.

12 — The Mercury, Pottstown, Pa. — Wednesday, August 3, 1983

GAO says nuclear evacuation plans are deficient

WASHINGTON (UPI) — Emergency evacuation procedures at nuclear power plants may be seriously deficient because the government has no minimum planning standards and no training requirements, the General Accounting Office charged Tuesday.

The GAO, Congress' investigative arm, leveled the heavy criticism at the Nuclear Regulatory Commission and the Federal Emergency Management Agency during a House Interior subcommittee hearing on emergency preparedness for the nation's commercial reactors.

Committee Chairman Edward Markey, D-Mass., said its investigation shows neither agency has a regulation "defining the minimally acceptable conditions necessary to justify the operation of a nuclear plant with respect to emergency preparedness."

The NRC and the emergency management agency have struggled for years to develop standards that local and state governments and utility companies can use to set up emergency evacuation procedures for the surrounding population in the event of an atomic reactor accident that releases deadly radiation.

In recent months, the agencies have encountered the most difficult emergency planning problems at two reactors near densely populated New York City — Indian Point in Westchester County and Shoreham on Long Island.

In the case of Shoreham, owned by Long Island Lighting Co., Suffolk County authorities have refused to cooperate in setting up evacuation plans, which is jeopardizing the start-up of the new plant.

In testimony to the subcommittee, GAO official Ralph Carlone said the study uncovered several major problems with the federal government's evaluation and approval of reactor emergency plans:

—"The Federal Emergency Management Agency has not established minimum standards that (test) excercises must meet," and has approved exercises that "did not provide ample opportunity to demonstrate response capabilities."

—"Plans for training federal, state and local government officials have not been implemented. As a result, it is uncertain whether public officials and emergency workers will know how to best respond in a nuclear power plant emergency."

—The agency "does not always require that all plan elements are tested, or verify that they are complying with federal criteria."

—It "does not have follow-up procedures for ensuring that deficiencies from previous exercises are corrected … . In some instances (it has) concluded that preparedness is adequate even though it has no evidence that deficiencies from earlier exercises have been corrected."

Carlone told the panel emergency planning around U.S. reactor sites also is hampered by lack of a "clear-cut method for funding" preparation and testing.

As a result, local communities that want to prevent or delay the start-up of a reactor, he noted, use "their refusal to participate in the emergency planning process to achieve their objectives."

Limerick Foes Ask: Is This Nuke Necessary?

By ALEXANDER REID
Daily News Staff Writer

In the farmlands and meadows of western Montgomery County, a legion of craftsmen and technicians works feverishly in the shadow of two 570 foot concave cooling towers.

The bustle of activity on this rural landscape belies the uncertainty surrounding Philadelphia Electric's Co.'s nuclear plant in Limerick Township, near Pottstown. As the scheduled spring 1985 start-up nears for the first of two reactors on the 587-acre site, the debate over the plant's necessity and dangers is heating up.

Foes argue that the twin reactor complex is unnecessary, uneconomical and unwanted.

And they note that the reactors have a life-span of about 40 years, rendering the plant useless well before the middle of the 21st century.

"We don't think there is enough water around here to operate the units. And the power that they're supposed to generate is not needed," said Phyllis Zitzer, head of Limerick Ecology Action, one of a host of citizens' groups opposed to Limerick. "With the rate hikes needed when this thing goes into service, it's not economical ... Nobody wants Limerick but PECO."

Limerick would be the closest nuclear power plant to Philadelphia and its 1.7 million residents, a fact that alarms an anti-nuclear power movement galvanized by the accident at Three Mile Island in 1979.

Philadelphia, 20 miles from Limerick, is not among the 43 municipalities devising emergency evacuation procedures. Only the towns within a 10 mile radius of the complex are required by the U.S. Nuclear Regulatory Commission to develop emergency plans.

In spite of the opposition — and lack of independent support for the project — PE is determined to complete Limerick.

During the primary election campaign in Bucks County last May, the utility poured $823,000 into an unsuccessful effort to influence voters to pass a non-binding referendum construction of the Point Pleasant water-diversion project. Water from the project is needed for Limerick.

On July 22, in response the state Public Utility Commission's 1982 order urging PE to cancel or suspend construction of Unit II at Limerick, the utility announced a plan to complete both units within five years.

Using a revolving loan agreement, arranged through a syndicate of 25 U.S. and foreign banks including New York's Citibank, PE would borrow $1.1 billion for the eventual completion of the Limerick project. Unit I would begin operation in 1985, Unit II in 1987.

Several consumer groups are preparing complaints with the commission on PE's plan. A decision is expected late next month.

One group, the Consumer Education and Protective Association, chartered a bus loaded with Limerick opponents yesterday and met with Citibank representatives in Manhattan to voice its criticisms.

"We want the banks to take into account the community's feeling on this," said Max Weiner, a consumer activist who heads CEPA. "If we demonstrate enough awareness, we think we can have the whole deal nixed."

PE says the plan will allow it to delay issuing mortgage bonds — the normal method for raising revenue — until the first reactor is included in the rate base and the company's financial condition improves. The utility, bled by Limerick costs over the years, currently has a bond credit rating of BBB-minus from Standard & Poor's Corp. and BaaJ from Moody's Investor Service. (The ratings are considered the lowest for "investment-grade" bonds; lower ratings would put the bonds in the "speculative" class, raising the interest rates the company would have to pay to borrow money.)

> *"We certainly believe that both units are in the best interest of our customers."*
>
> **Neil McDermott, Philadelphia Electric Co. spokesman**

PUC approval of the financing arrangement would represent significant progress toward completion of a project first proposed in 1969.

When construction began on the reactors in 1974, PE estimated Limerick would be completed by 1980 at a cost of $1.5 billion.

Construction delays and inflation have pushed the price tag for the units up to what officials estimate will be nearly $6 billion when they are completed. That will be about half of PE's assets.

For PE's 1.3 million customers, the plant will mean hefty rate increases if the commission approves the financing plan. Before each reactor goes into commercial operation, PE will seek 20 percent rate increases.

PE officials maintain that the twin units are needed to replace costly and soon-to-be outmoded means of energy production, such as oil-fired systems.

"We certainly believe that both units are in the best interest of our customers," said Neil McDermott, a company spokesman. "We have given the commission a plan that we feel is workable to the completion of both, and we are looking to complete both reactors."

Limerick's opponents, rallied by the proposed financing plan, do not share PE's optimism. They say the utility is embarking on a financially risky course to push the nuclear plant into operation.

"Their financial agreement attempts to trade claimed short-term benefits for long-term burdens," said Steve Hershey, a Community Legal Services lawyer who represented several citizens' groups during a 1980 PUC investigation of Limerick.

"For instance, the banks say that Unit I has to go into the rate base in a timely manner, which means by 1985. Suppose something goes wrong with construction or the company has problems working out the evacuation procedure, which they are having trouble doing now? Let's say they don't get their license within the next year. The operating date could be held up and the banks could withdraw the loan, and that would be a disaster for PECO and obviously their customers."

Critics of the arrangement also target the revised construction schedule, which they say violates the 1982 PUC order that PE scrap or delay Unit II until the first reactor is completed. The simultaneous construction of both reactors, it said, poses financial consequences for ratepayers and stockholders.

Later this year, as they complete work on Unit I, a workforce of about 200 craftsmen and engineers would resume work on the second reactor, which today is 30 percent complete.

By 1985, when the first reactor is scheduled to go on line, 1,900 workers will be engaged in construction on Unit II and PE will have spent $501 million on the reactor.

PE says construction on both units is feasible now because the plan hurdles the financial obstacles faced by the company last year, when the PUC first issued its order.

"When the commission made that ruling, they didn't think we could raise the money to build Unit II until we built Unit I," said Joseph F. Paquette Jr., PE's vice president for finance and accounting. "We feel ... we can convince them ... that we can carry out work on both units."

THE PENNSYLVANIA STATE UNIVERSITY
104 DAVEY LABORATORY
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College of Science
Department of Physics

Area Code 814

8 August 1983

U.S. Nuclear Regulatory Commission
Washington, D.C., 20555

Attention:

Director, Division of Licensing

Dear Director:

Enclosed are my comments on the Draft Environmental Statement related to the operation of the Limerick Generating Station, Units 1 and 2, NUREG-0974. Please note that the opinions and calculations presented do not necessarily reflect the position of the Pennsylvania State University.

I will be looking forward to the Final Environmental Statement. Would you also please send me a copy of that Final EIS when it is available.

Sincerely,

William A. Lochstet

Wm. A. Lochstet, Ph.D.

50-352 353

C002

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Some Health Consequences
of Limerick 1 and 2
by

William A. Lochstet, Ph.D.

The Pennsylvania State University
August 1983

WAL-1 The Nuclear Regulatory Commission (NRC) has attempted to evaluate the health consequences of the operation of the Limerick nuclear power plants in the Draft Environmental Statement, NUREG-0974 (Ref. 1). The health consequences of the radon -222 released from the mill tailings and mines, needed to fuel the plant, are evaluated for the first 1000 years in Appendix C. This evaluation states that the radon emissions increase with time (Page C-5, Ref. 1), and there is no suggestion that there is any reason to believe that these emissions will stop after 1000 years, or even to decrease.

In fact, these emissions continue for a very long time, being governed by the 80,000 year half life of the thorium-230, and the 4.5 billion year half lifeof the uranium-238 in the mill tailings. The amount of material covering the tailings also effects the amount of radon released to the atmosphere. The thorium situation has been adequately discussed by Pohl (Ref. 2) in 1976. The impact of the uranium-238 as a source of radon was recognized by the NRC in GESMO (Ref. 3), which is one of the references of Appendix C of this Draft Report (Ref. 1).

Appendix C of this Draft (Ref. 1) is written on the presumption of a 1000-MWe LWR plant operated at an 80% capacity factor (Page C-1). This will require about 29 metric tons of reactor fuel. With uranium enrichment plants operating at a

* Affiliation for identification purposes only.

0.2% tails assay, 146 metric tone of natural uranium will be required, and 117 metric tons of depleted uranium will be left over. With a uranium mill which extracts 96% of the uranium from the ore, a total of 90,000 metric tons of ore is mined, containing 152 metric tons of uranium (Ref. 4). The uranium mill tailings will contain 2.6 kilograms of thorium-230 and 6 metric tons of uranium. As Pohl has pointed out (Ref.2), the thorium decays to radium-226, which in turn decays to radon-222. This process results in the generation of 3.9×10^8 curies of radon-222, on a time scale determined by the 8×10^4 year half life of thorium-230.

The 6 metric tons of uranium contained in the mill tailings decays by several steps thru thorium-230 to radon-222. This process occurs on a time scale governed by the 4.5×10^9 year half life of the uranium-238, the major isotope present(99.3%). The total amount of radon-222 which will result from this decay is 8.6×10^{11} curies.

The 117 metric tons of depleted uranium from the enrichment process is also mainly uranium-238, which also decays. The decay of these enrichment tails results in a total of 1.7×10^{13} curies of radon-222. The impact of these decays were listed by the NRC in GESMO (Ref. 3).

The population at risk is taken to be a stabilized USA at its present level and present distribution. This is similar to that taken by the Draft (Page C-3, Ref. 1). The NRC has suggested that a release of 4,800 curies of radon-222 from the mines would result in 0.023 excess deaths (Ref. 5). This provides a ratio of 4.8×10^{-6} deaths per curie.

At present some recent uranium mill tailings piles have two feet of dirt covering. In this case, the EPA estimate (Ref. 4) is that about 1/20 of the radon produced escapes into the air. Thus, of the 3.9×10^8 curies of radon from the thorium in the mill tailings, only 1.9×10^7 curies will get into the air. With the estimate of 4.8×10^{-6} deaths per curie, this results in a total of 90 deaths.

The 8.6×10^{11} curies of radon produced by the uranium in the mill tailings will similarly have 1/20 escape to the air. With the same method as was used above, the result is 200,000 deaths.

The uranium enrichment tailings are presently located in the eastern part of the USA. If these are buried near their present location it is taken that 1/100 of the radon will escape to the air, due to the higher moisture content of the covering soil. An additional reduction factor of 2 is taken to account for the more eastern location, and the fewer people downwind, to the east of the sites. With the NRC estimate of 4.8×10^{-6} deaths per curie, the result is 400,000 deaths.

The NRC estimate is about 2 deaths in the draft (Ref. 1) is thus more than 100,000 times too low as compared to the sum of 600,000 deaths as shown above. This is due largely to the arbitrary, erronious, immoral, incorrect procedure of stopping at the end of the first 1000 years.

The fact that these doses and death rates are less than background is interesting (Page C-6, Ref. 1), but absolutely irrelevant. The major federal action to be considered by the the NRC is not whether or not to license background radiation, but whether or not to license the Limerick plants. This is what NEPA requires.

It is hoped that these comments are useful in preparing the Final EIS.

References

1 Draft Environmental Statement related to the operation of Limerick Generating Station, Units 1 and 2.; NUREG- 0974, Draft, NRC, June 1983

2 R.O. Pohl, "Health Effects of Radon-222 from Uranium Mining", Search, 7(5), 345 - 350 (August 1976)

3 "Final Generic Environmental Statement on the Use of Recycled Plutonium in Mixed Oxide Fuel in Light Water Cooled Reactors", NUREG-0002, NRC , (August 1976)

4 "Environmental Analysis of The Uranium Fuel Cycle, Part I - Fuel Supply", EPA-520/9-73-003B, EPA, (October 1973)

5 "Health Effects Attributable to Coal and Nuclear Fuel Cycle Alternatives", NUREG-0332, Draft, NRC, (September 1977)

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V. S. BOYER
SR. VICE PRESIDENT
NUCLEAR POWER

August 15, 1983

Mr. Darrell G. Eisenhut, Director
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: NUREG 0974: Draft Environmental Statement Related to the Operation of Limerick Generating Station, Units 1 and 2, Docket Nos. 50-352 and 50-353

Dear Mr. Eisenhut:

We have reviewed the subject DES and our comments are enclosed.

Sincerely,

[signature]

Encl.

See attached service list

C002

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PDR ADOCK 05000352
D PDR

cc: Judge Lawrence Brenner (w/enclosure)
Judge Richard F. Cole (w/enclosure)
Judge Peter A. Morris (w/enclosure)
Troy B. Conner, Jr., Esq. (w/enclosure)
Ann P. Hodgdon, Esq. (w/enclosure)
Mr. Frank R. Romano (w/enclosure)
Mr. Robert L. Anthony (w/enclosure)
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Mr. Thomas Gerusky (w/enclosure)
Director, Pennsylvania Emergency Management Agency (w/enclosure)
Mr. Steven P. Hershey (w/enclosure)
Angus Love, Esq. (w/enclosure)
Mr. Joseph H. White, III (w/enclosure)
David Wersan, Esq. (w/enclosure)
Robert J. Sugarman, Esq. (w/enclosure)
Martha W. Bush, Esq. (w/enclosure)
Spence W. Perry, Esq. (w/enclosure)
Atomic Safety and Licensing Appeal Board (w/enclosure)
Atomic Safety and Licensing Board Panel (w/enclosure)
Docket and Service Section (w/enclosure)

COMMENTS

ON

NUREG-0974

DRAFT ENVIRONMENTAL STATEMENT

RELATED TO THE OPERATION OF

LIMERICK GENERATING STATION

UNITS 1 AND 2

DOCKET NOS. 50-352 AND 50-353

CHAPTER/SECTION		COMMENT
	SUMMARY AND CONCLUSION	
PECO-1	Page v	Item (2), second paragraph, third sentence, should read ". . . using water from the Schuylkill River, Perkiomen Creek, and the Delaware River."
PECO-2	Page viii	Item (4)(u): See comments below on pages 5-77, 5-93, and 5-94.
	FOREWORD	
		No Comment
	INTRODUCTION	
PECO-3	Page 1-1	Section 1, second paragraph, first sentence: Suggested rewording, "The generating system consists of two boiling water reactors, two steam turbine-generators, heat-dissipation systems, and associated auxiliary facilities and engineering safeguards."
	PURPOSE AND NEED FOR ACTION	
		No Comment
	ALTERNATIVES TO PROPOSED ACTION	
		No Comment

-1-

<u>PROJECT DESCRIPTION AND AFFECTED ENVIRONMENT</u>

PECO-4	Page 4-4	Table 4.1: We believe that two of the values in this table are in error. For makeup from the Delaware/Perkiomen during June through October, the range should be 52.1-57.4 and the average should be 55.7 ft^3/sec based on the values as given in EROL Table 8.3-1.
PECO-5	Page 4-7	Section 4.2.4, Cooling System, first paragraph: The following should be added to the third sentence ". . .with two units operating and when the downstream river water temperature is less than 15°C. . .". The statement should also note that water may be withdrawn from the Schuylkill River regardless of temperature during April, May, and June, provided the river flow is above 1791 ft^3/sec.
PECO-6	Page 4-12	<u>Main Stem of Perkiomen Creek Intake</u>, last sentence of the first paragraph: This should be corrected to state that the system will be activated manually from a control panel located at the pumphouse. There are no automatic means to activate the system.
PECO-7	Page 4-14	Section 4.2.6.2, Cooling Water Systems: While the DES indicated a value for average concentration factor for the June-through-October period of about 3.7, our expectation of the range of average concentration factors is 2.9 to 3.4.
PECO-8	Page 4-18	Section 4.2.7, This discussion should be updated to be consistent with Rev. 14 to the EROL submitted July, 1983. Therefore, the third paragraph, first sentence, "23km (14.5 miles)" should be changed to "22km (13.5 miles)". Seventh sentence, "or Tubular steel poles" should be added after "Wide flange steel towers".
PECO-9	Page 4-53	Table 4.13, footnote giving source: as stated on page 4-51 the source of this data is the staff not the "ER-OL" as shown.
PECO-10	Page 4-54	Last paragraph, first sentence, "(Table 2.1-A)" should be "(Table 2.1-19)".

-2-

PECo-11 Page 5-9

Third paragraph, first sentence; We believe "and" should be inserted after the phrase "do not exceed one unit"and before "would".

PECo-12 Page 5-18

Section 5.3.3.2, Wedgewire Screen Bypass Velocities at Point Pleasant: The ASLB in its Partial Initial Decision, dated March 8, 1983, cited Applicant's testimony and exhibits regarding velocities under Findings, items 35 and 66. At flows of 3,000 cfs the river velocity is at or in excess of 1 fps. It is requested that the second sentence be corrected by the deletion of the words "0.77 fps, with the most likely velocity about". At flows of 2,500 cfs the river velocity is 0.8 fps. It is requested that the third sentence be corrected by the deletion of the words "at least 0.64 fps, with the most likely value."

Section 5.3.3.3, Sedimentation and Erosion in Perkiomen Creek, first paragraph: The statement that Delaware River water will enter the East Branch Perkiomen Creek through a 48 inch diameter pipe is incorrect. As shown on EROL Figure 2.4-7d, this pipe is 42 inches. Only the first 12,187 feet of the pipeline, as it leaves Bradshaw Reservoir, is 48 inch. The remaining 23,140 feet of the pipeline is 42 inch.

PECo-13 Page 5-25

Next to last paragraph, first sentence; We believe that the word "not" should be inserted between "will" and "adversely".

PECo-14 Page 5-28 and Page 5-91

Section 5.5.1.4, Pipeline Corridor Maintenance and 5.14.1 Terrestrial Monitoring: The DES expresses concern about the erosion potential of the slope adjacent to State Highway 32 at Point Pleasant once construction of buried pipeline is complete. It should be noted that this pipeline was to be installed to serve the public water supply needs of Bucks and Montgomery Counties prior to Applicant becoming involved as a water customer of the Neshamany Water Resources Authority and that this pipeline is not owned and will not be constructed or operated by Applicant. The NWRA has considered short and long term impacts and is subject to all conditions in the permits it has received related to this work from the DRBC, DER and COE.

PECo-15	Page 5-37	Section 5.8, First paragraph: The salary of the work force given in EROL (8.1-4) is $44 million in 1990 dollars. The DES estimates $24.8 million in 1982 dollars. (This would be a compound escalation rate of 7.4%) Section 5.8, Third paragraph: The public utility realty tax of $27 million per year in 1990 dollars is given in EROL (8.3-8). The DES estimates a value of $9 million per year in 1982 dollars. (This would be a compound escalation rate of 14.7%) The use of these two disparate rates is inconsistent.
PECo-16	Page 5-52	Table 5.8, The fourth and fifth columns for the last two entries on this page are incorrect. For the next to the last entry 1988 (partial) Sample type "Direct Radiation" under "Analysis" column should read "Gamma dose" and under "Frequency of Analysis" should read "monthly". The last entry Sample type "Air (particulate and iodine)" under "Analysis" should be added "Radioiodine (I-131)" and under "Frequency of Analysis" should be added "___" (See EROL Table 6.1-45).
PECo-17	Page 5-56	Table 5.9, Seventh entry from top of page: The Sector for the Poplar substation, code "31D2" is "NW" not "NNW" as shown.
PECo-18	Page 5-77	Section 5.12.2.1: The Bradshaw Reservoir design engineer has been directed to implement the ventilating louvre modification recommendation.
PECo-19	Page 5-90	Figure 5.8: The location of residences C and D are inaccurately shown on this figure. There are no residences between the plant and the river. Refer to EROL Table 2.1-37.
PECo-20	Page 5-93	Section 5.14.4.1, Point Pleasant Pumphouse: A commitment is acknowledged for construction of physical barriers (walls) if necessary.
PECo-21	Page 5-94	Section 5.14.4.2, Noise Monitoring, Bradshaw Reservoir: The Bradshaw Reservoir design engineer has been directed to implement the noise monitoring program.

PECO-22 Pages 6-2, 6-3, and 6-4

The reduction in generating costs of $84 million unit/year presented in Table 6.1 and discussed in Section 6.4.2 underestimate the operating savings attributable to Limerick.

Our estimate of these savings are presented in EROL Table E320.1-1 (Revision 11, March 1983). As shown in this table, during the first complete year of one unit operation (1986), the savings are estimated to be $188.8 million per unit/year and during the first complete year of two unit operation (1989) to be $258.2 million per unit/year. These estimates are escalated dollars based on a 70% capacity factor.

If these dollars are brought back to 1985 costs (at 8%/year), the savings for 1986 and 1989 are approximately $175 million and $190 million, respectively. Even if a 55% capacity factor is used, the estimated resultant savings are $143 million per unit/year for 1986 savings and $152 million per unit/year for 1989 savings in 1985 dollars using the same method of calculation.

The energy savings of $84 million per unit/year presented in Table 6.1 of the DES is based on replacement of Limerick by ". . . installed fossil units on the applicant's system. . ." (Section 6.4.2).

The calculated cost differential appears to be based on our coal costs. This is not realistic. Any installed coal units on our system will have little, if any, replacement energy available since these units will be operated at, or near, base load even with the Limerick units in service.

Therefore, replacement of the Limerick energy with our installed fossil units will be bounded in cost by replacement with all oil generation on the high side and our oil generation and some coal interchange on the low side.

For the purpose of verifying our calculations, the approximate value of these savings can be estimated by the following calculation. Using the DES basis of the 10 million MWh/year and either all oil replacement, or 50% oil and 50% coal replacement; the fuel savings are approximately:

	10 Million MWh/Year	
	100% Oil @ $5.20/Mbtu	50% Oil @ $5.20/Mbtu 50% Coal @ $2.00/Mbtu
Fossil Fuel Costs*	$556,500,000	$383,250,000
Limerick Fuel Costs**	$ 88,000,000	$ 88,000,000
Net Savings	$468,500,000	$295,250,000

*@ 10,500 btu/kWh
**@ 8.8 mills/kWh

Thus, on a one unit basis at 55% capacity factor (5 million MWh per year) the above calculation shows fuel savings of approximately $148 million/unit/year to $234 million/unit/year. Using the same method of approximation at a 70% capacity factor, the 10 million MWh/year would increase to approximately 12.9 million MWh/year. The 50% oil/50% coal savings would then increase to approximately $190 million/unit year.

Our more detailed calculations shown in EROL Table E320.1-1 and described earlier are within the bounds of this approximate calculation.

PECo-23 Page 6-8

Table 6.1 Benefit - cost summary for Limerick: The table indicates that the effect on historic and archeological resources of Limerick are moderate. This classification appears to be inconsistent with the discussion in Section 5.7 and based upon that discussion Applicant believes that the classification should be 'small' or 'none'. Additionally to update the discussion in Section 5.7, it should be noted, regarding work by the NWRA at their Point Pleasant pumping station, the Corps of Engineers did include in their permit a condition that work shall be performed in accordance with the "Memorandum of Agreement". Construction work started in January 1983 and as required an archeologist is on site.

-6-

LIST OF CONTRIBUTORS

No Comment

LIST OF AGENCIES, ORGANIZATIONS, AND PERSONS TO WHOM COPIES OF THIS ENVIRONMENTAL STATEMENT ARE BEING SENT

No Comment

RESERVED FOR NRC STAFF RESPONSES TO COMMENTS ON THE DRAFT ENVIRONMENTAL STATEMENT

No Comment

APPENDIX A

No Comment

APPENDIX B

No Comment

APPENDIX C

No Comment

APPENDIX D

PECo-24 Page D-2

The dose assessment presented is an extremely conservative treatment of the expected effects of gaseous and particulate effluent releases. While the analysis does serve a purpose in showing that even with the most conservative assumptions the plant meets the criteria of 10 CFR Part 50, Appendix I, these results should not be used for any purpose in which realistic calculations are required. This should be made clear in this Appendix.

The most conservative aspect of the assessment is the assumption that all releases in those sectors downwind of the natural draft cooling towers should be treated as ground-level releases, rather than using the wake split approach of Regulatory Guide 1.111, Rev. 1. While it is a well-known fact that large structures such as cooling towers do produce a wake area of increased turbulence during some meteorological conditions, the staff has treated the effluent as if it were brought entirely to the ground during all meteorological conditions. This assumption is clearly ultra-conservative for the following reasons:

1) Cooling tower wake effects do not exist during low wind speed conditions.

2) Hyperbolic cooling towers do not produce sharp downdrafts at moderate to high wind speeds causing 100% ground level releases. Rather, enhanced turbulence results.

These phenomena have been documented in wind tunnel studies and field tests performed for the Rancho Seco and Paradise plants in 1971.

APPENDIX E

No Comment

APPENDIX F

No Comment

APPENDIX G

No Comment

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COUNSEL

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August 15, 1983

Division of Licnensing
Nuclear Redgulatory Commission
Washington, D.C. 20555

Re:Commmments on DEIS NUREG -0974

Sir:

Enclosed please find comments of Del-Aware Unlimited Inc on the Limerick DEIS, and enclosures. As stated, additional documents referred to are available from the undersigned.

Sincerely,

Robert J. Sugarman

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COMMENTS ON NRC EIS

DATED AGUST 15, 1983

SD-1 The NRC EIS is completely deficient and fails to discharge NRC's responsibility completely. In December, 1980, NRC committed to perofrm an EIS on the entire water related impacts of Limerick on the Delarware Rvier, and specifically in January, 1981, informed PECO that it would do so.

On the basis of this, the majortiy of DRBC, which had been prepared to reject the water allocation, voted to approve it. These facts are documented in correspondence and the DRBC minutes, as well as EPA memos and the depositicn transcript of George Pence in the PID proceeedings. These materials are in NRC files.

The EEIS completely fails to address these matters independently, insread relying totally on DRBS and DER materials. The DRBC materials are no different than those available in December 1980 then the commitment was made; the DER materials are simply a summary of the DRBC materials, as documented in the 1982=83 Envrionmental Hearing Board proceedings on apppeals from the DER action. These materials are also available from this source.

The EIS Also completely ignores the testimny presented in the DER - EHB proceeding relating to the impacts of the diversion on water quality and erosion in the East Branch Perkiomen Creek. These impeacts are thoroughly presented and authenticated by professionals such as Edwin Beeemer, Jon Philllippe, Michael Kaufmann and others. They show - including their testimony in the Pa. PUC in the Bradshaw Reservoir app licatiuon docket still pending that there will be a devastating effect on the East Brnach.

The EIS Also ignores the DRBC's recent admission that there is inadequate water in the river to satisfy interim or final salinity stndards in the river. New Jersey is already being forced to loook elsewhere to driunking water for the City Camden as a direct conseuqence.

The EIS also fails to consider the effects of Merrill Creek, although DRBC has found, subsequent to the CP EIS that its construction is necessary for Limerick and the members ahve committed themselves to its consturction, subject only to environmental reviews/

SD-2 The EIS ignores the Pennsylvania PUC decision thar Limerick 2 is a financial disaster for the ratepayers, and instead claims socio-economic beneifts from construction of Limerick , a clear inconsistnecy and an outragoues insult to the concept of socio-economic analyysis.

SD-3 The EIS faile to deal with the loss of a spawning area for American shad, a species detemind to be economically vital to the Commonwaleth of Pa., and that no proper study has been performed to determine if short nosed sturgeon, an endangered species , are present, and sscetiplbe to damage. It deals only with the existence of these species in the river, not impact on its populations.

SD-4 The EIS fails to acknowledge the harm caused to the Delaware Canal, a National Historic Landmark, and indeed, fails to acknowledge the existecne of the Landmark.

SD-5 The EIS, by cumulatively ignoring and failing to deal with all of these facts and damages caused by the project, as well as the fact that it would now not be built at all but for Limerick, as well as the existence of alternatives for L imerick not available in 1973 == completely and systemcatically betrays the functions of an v EIS, and instead of identifying impacts, covers them up. Instead of looking at alternatives, it ignores them.

Attached are the most recent letter from U.S. Fish and Wildlife Service documenting alternative sources of warer for Limerick, the commenters' Prposed Findings of Fact in the Pa. POUC proccedings, which summarize the testimony showing adverse impacts on the Perkiomen and the existence of alternatives, and the most recent DRBS Position Paper, acknowledging the inadequacy of water in the River to support salinity requirements. Also attached are the letters of the Bucks County Commissioners announcing their withdrawal from rhe project, which means that it is only Limerick which is causing the environmental consequences of the pump station -- not as found in the CP N EIS- that the Limerick impacts were only the incremtnal size of the diversioon.

BEFORE THE
PENNSYLVANIA PUBLIC UTILITY COMMISSION

In re: Application of Philadelphia Electric Company for a Finding of Convenience and Necessity	: : : :	Application Docket No. A-00103956

PROPOSED FINDINGS OF FACT OF
DEL-AWARE UNLIMITED, INC. ET AL.

Pursuant to the Commission's procedures, Intervenors Del-AWARE Unlimited, Inc. et al. hereby submit the following proposed findings of fact:

I. GENERAL

1. While the Applicant has denominated its application as seeking a certificate to construct a pumphouse, in its original case in chief it chose to justify the construction of the pump house as part of a larger integrated water transfer system, consisting of a diversion from the Delaware River and pipeline to a reservoir, designated Bradshaw Reservoir, on the bank on which the pumphouse would be constructed, thence via pipeline to discharge in the East Branch of the Perkiomen Creek, and then to be transported approximately twenty-five (25) miles downstream to a take off point at Graterford, and thence via a pumphouse and pipeline some seven (7) miles to Limerick. The last mentioned pumphouse was the subject of a separate application

filed with the Commission. (PECo 32 at 4-6; I-8; Boyer, Tr. 745-46)

2. In addition, operation of the system as contemplated by the Applicant includes a reservoir upstream of the intake point on the Delaware River, to be known as Merrill Creek, into which water would be pumped from the river, for discharge and take up via the proposed system during times of low water in the Delaware River. Approval of this associated facility is presently pending before the Delaware River Basin Commission. (Phillippe, Tr. 160)

3. The applicant's contention that the proposed facility was reasonably necessary was based on consideration of the utilization of the overall system, and not merely the "building known as the Bradshaw pumphouse, nor the Bradshaw Reservoir as a whole, nor the water supply system as a whole. (Boyer Testimony, p. 14; Boyer, Tr. 746)

4. There is no evidence to support the reasonable necessity of the pumphouse by itself, or the reservoir and pumphouse by itself, or the water supply system in isolation from the operation of the Limerick Generating Station.

5. The pumphouse building is a physical part of a proposed Bradshaw Reservoir, being located in and as a integral part of the dikes of the proposed reservoir. The dikes are proposed to be 900 feet long on each side, and 5 to 20 feet high. The pumphouse will be built on top of the western dike, and will house five pumps, which will pump water from the reservoir via an intake pipeline, and after

pumping, through a further pipeline, approximately 30,000 feet long, ending in an outlet and dissipator at the East Branch of the Perkiomen Creek. Both the reservoir and the East Branch outlet are integrally and functionally related to the pumphouse. (I-8, I-1; PECo 32 at 5, 12)

II. IMPACT ON THE EAST BRANCH

A. Project Facilities And Operation

6. As proposed, the four pumps will pump up to 71 cubic feet per second cfs of water through the pipes, discharging into the East Branch. The average pumping rate into the East Branch of the Perkiomen for each unit will be up to 26 cfs plus 2.6 cfs allowance for losses in transit, for a total of 55 cfs plus 5 cfs, or 60 cfs for two units at Limerick. (Hershey, Tr. 478; Phillippe, Tr. 1444)

7. The pumping season for utilization at Limerick will depend on flow levels and temperatures in the Schuylkill River, where Applicant is permitted to obtain its water subject to certain limitations imposed by the DRBC in its 1975 Docket Decision. (Weston Testimony, pp. 16-17)

8. In its operating requirements, DRBC required that Applicant maintain a minimum discharge of 10 cfs during winter months, and a minimum flow of 27 cfs once cooling water pumping begins in each season. These minimum flow requirements were designed to maintain the flow of water in the stream to maintain it in its new regimen after the

introduction of the discharge program. (Hershey, Tr. 491; PECO-5d at 6)

B. Increase In Median Flow

9. Present flows in the East Branch of the Perkiomen Creek at the nearest calculated point below the discharge location, Elephant Road, are 1.4 cfs median flow, and 112 cfs annual recurrence flow. Both values represent calculated flows based on measured flows in other watersheds, transferred on a basis of watershed size, and do not represent actual measurements in the East Branch of the Perkiomen Creek, as there are no gauging stations on the East Branch. (Dornstreich, Tr. 43, 91; PECO-32, Section IV Table 2)

10. Introduction of the diversion program would increase the present median flow by approximately 40 times, or several orders of magnitude, and would, when added to local flood flows cause a significant increase in the frequency of the occurrence of the annual flood, as well as other high flood levels at Elephant Road. (Hershey, Tr. 485-86, 570)

11. The relevant section of the East Branch of the Perkiomen for evaluation of impact is an area beginning at the point of discharge and extending downstream to dams and lakes into the Borough of Perkasie and Sellersville, below which the stream is affected by a discharge from a sewage treatment plant, and where it would be substantially less affected by the introduction of the diversion. Upstream of

those installations, the East Branch remains a relatively low median flow stream, and for a substantial distant downstream, retains a character essentially similar to that at Elephant Road. (Beemer, Tr. 1346-47; PECo-32 at 43; Phillippe, Tr. 1444-45)

12. The East Branch would be susceptible to changes in its present configuration due to several types of factors, i.e., the gradual effects of the long term change in median flow, and the adjustment or reaction to the increased frequency of flood flows. (Beemer, Tr. 1347-51; Phillippe, Tr. 1445-49; Hershey, Tr. 489-92; Kaufmann, Tr. 1531-33; Tourbier, Tr. 320-323)

13. The increase in the median flow by several orders of magnitude, as would occur with the proposed operation in the area above Perkasie and Sellersville, will cause erosive changes in that reach of the East Branch. (Phillippe, Tr. 1445; Beemer, Tr. 1347, 1367; Hershey, Tr. 489-90)

14. The erosion will result in the widening of the stream, particularly in the vicinity of meanders and curves, where the stream will impact the present banks with particular force, and exacerbate the present relative tendency of such areas to erode. (Beemer, Tr. 1360-61; Hershey, Tr. 489-90)

15. The extent of a stream's carrying capacity within its channel is determined by the force that is exerted against that channel, and its capability to resist such force. With respect to continuing flows not exceeding bank

full conditions, the relevant characteristics of the flow include volume and sediment levels and velocity. Water moving at a higher velocity in greater volumes and with less sediment will exert more force on the stream banks, and will tend to absorb sediment from the stream channel as it seeks to obtain equilibrium with the stream. (Phillippe, Tr. 1427-28, 1433-34)

16. The characteristics of the channel relevant to erosion include the extent of meanders, the nature of the materials in the bottom and side of the channel, and the existing cross sectional area for flow, as well as roughness of the bottom and the gradient of the channel. (Hershey, Tr. 489; Phillippe, Tr. 1446; Beemer, Tr. 1349-51, 1360-62, 1368)

17. The water to be proposed to be introduced into the East Branch will be substantially free of sediment. (Phillippe, Tr. 1440-41; Beemer, Tr. 1377; Edinger, Testimony, p. 5)

18. The result of the introduction of flow will be a substantial increase in velocity, which will increase median velocity from .61 fps. to 3.02 fps. at the Elephant Road location, and will have substantial increases down to the Perkasie, Sellersville area (4 miles down stream). (I42, PECo 32 Section IV, Table 2; Hershey, Tr. 490-500)

19. As the stream increases its channel size to respond to the additional force, it may cause lower

velocities in some areas, but may increase velocity in the meander curves. (Beemer, Tr. 1409)

20. With respect to the existing channel characteristics, most of the bottom sections of the East Branch channel consist of bedrock or its equivalent, in the relevant areas, particularly upstream of Route 313, (about one mile downstream from the discharge) and thus there is little if all, likelihood of erosion of the channel bottom. As a result any additional channel capacity will be created in the side banks. (Beemer, Tr. 1349-50)

21. East Branch channel sides or banks are relatively highly susceptible to erosion in that they consist of silty loam of the Bowmansville classification, which are classified by the Soil Conservation Service as highly susceptible to erosion. Moreover, an accurate analysis of erodability of the East Branch silty loam, taking into account the interaction of the various component of fine silts and clays, has never been conducted. (Beemer, Tr. 1355-57; I-43-44; Hershey, Tr. 530-36)

22. The silty clay loam classification of the East Branch soils is consistent with soil conservation maps and Beemer's testimony is consistent with the findings of Applicant's consulting engineers in their preliminary report on the East Branch Perkiomen Main, in the core sample taken at the location closest to the East Branch. (Beemer, Tr. 1555-58; Exhibit I-30)

23. The Testimony of Mr. Tourbier, a site planner and landscape architect specializing in water management and site planning, corroborates the testimony of Messrs. Phillippe, Beemer, and Hershey. Mr. Tourbier's analysis confirms that site planners would anticipate substantial additional erosion as a result of additional flood flows and as well as the energy impacts of additional of substantial increases in median flow. (Tourbier, Tr. 313-4, 320)

24. Introduction of a maximum 65 cfs flow from a 3.5 foot pipe into a narrow stream at median flow 1.4 cfs will produce rapid erosion at the point of discharge and move prolonged erosion downstream. (Tourbier, Tr. 321-22, 326)

25. The East Branch is already experiencing slumping of its stream banks, caused by undercutting and sliding into the stream, which indicates that the streambed is highly erosive. (Tourbier, 328)

26. The conclusions of witnesses Phillippe, Beemer, and Hershey with regard to the erosive effects, based on the foregoing analysis, are authoritative and compelling, both because of the compelling nature of the rationale which they advanced in support of their conclusions, and because of their qualifications and support for their conclusions within the literature.

27. Mr. Beemer has had substantial experience in evaluating erosive effects of changes in the normal stream regimes, and has provided recommended specifications to prevent erosion in connection with such actions, which have

been implemented and which have prevented such erosion. (Beemer, Tr. 1316, 1322)

28. Mr. Beemer has substantial expertise with regard to evaluation of the nature of the geological and soil mechanics characteristic of stream channels, both bottoms and banks, and provided a clear and compelling description, confirmed by Applicant's own authorities, and Soil Conservation Service classification of the bottom and channel banks of the East Branch of the Perkiomen, based on a personal onsight examination of the channel detail in the area above Route 313, and samples of it between Route 313 and Perkasie Borough. (Beemer, Tr. 1346-47)

29. Mr. Beemer is also, by the same skills, well qualified to evaluate the sedimentary loads in the Delaware River water to be transported, and provided a full and compelling basis for concluding that the soils are in fact essentially clear of colloidal material, and would be low in sediment generally. (Beemer, Tr. 1370-77)

30. Mr. Beemer demonstrated a substantial knowledge of the process by which increase of flow regimes would affect channel size and this provides additional support for his conclusions. (Beemer, Tr. 1349-51)

31. Mr. Phillippe is a highly qualified civil engineer, with significant experience in dealing with erosive effects of flow regimes, and soil mechanics, which is the evaluation of the means by which soils are impacted in

connection with forces operating upon them. (Phillippe, Tr. 1423-25)

32. Mr. Phillippe's analysis of the process and the factors which would govern the extent of the erosion, is clear and compelling, well related to the authorities which he cited such as "the Natural Channel of Brandywine Creek, Pennsylvania" by M. Gorden Wollman, as well as the standard reference, American Society of Civil Engineers Bulletin No. 54, which, utilized by him, make it clear that increase in volume of water have a substantial effect on flow as well as the fact that a channel not designed, constructed and aged as a straight channel for such steady flow, would erode at substantially lower velocities than a channel created and aged for irrigation flows, and that erosion would be further increased to the extent that the diverted water was free of sedimentation, thus providing potential energy to remove soils from the banks. (Phillippe, Tr. 1431-34)

33. Mr. Phillippe's conclusions were further supported by his having secured and analyzed the principal authority relied upon by Applicant's witness, Mr. Steacy, the Fortier and Scobie paper (cited from the Brater and King reference of Steacy) (PECo 34 at 7-23). (Phillippe, Tr. at 1438)

34. In studying the Fortier and Scobie paper, Mr. Phillippe demonstrated that the Fortier and Scobie recommendations of maximum velocity to avoid erosion are based on the assumption that the channel has been aged, and that it is straight, as well as on the characteristic of the soil

and the transported water. The curves in the East Branch of the Perkiomen, as a meandering stream, require a reduction of up to 25% in the velocity according to Fortier and Scobie. (Phillippe, Tr. 1438-1443)

35. As a water quality engineer, Mr. Phillippe is also well qualified to have concluded that the Delaware River water being transported based on values for total suspended solids and turbidity reported in the Applicant's studies, is essentially clean water, which increases its potential for removing material from the channel banks, thus creating erosion. (Phillippe, Tr. 346-47; PECo 32 at Section V, p.1)

36. Based on the foregoing, Phillippe properly applying the figures contained in ASCE 54 and Scobie and King, concluded that the velocity projected for the transport of water by Applicant are substantially in excess of the minimums which would cause erosion in the East Branch down to Perkasie. This specifically includes the consideration of the fact that the channel is not a straight channel, is not aged but is a continually changing channel, that it was not formed or designed for the purpose, and the transport of water would be essentially clean. (Phillippe, Tr. 1438-43)

37. Phillippe's explanation of the reason for the influence of clean water enhancing erosion is particularly qualified in view of his work in nonpoint source erosion, demonstrating that the reduction in sediment in normal runoff had been observed to cause increases in erosion in the stream. (Phillippe, Tr. 1427).

38. Hershey's analysis, similarly supported by authorities, further corroborates that of Mr. Beemer and Mr. Phillippe, and based on application of sound principles, further supports their conclusions. (Hershey, Tr. 489-91)

39. Kaufmann's analysis of the susceptiblity to erosion from a practicing biological biologist standpoint, further confirms the analysis of Messrs. Phillippe, Beemer, and Hershey. (Kaufmann Statement, EHB Tr. 616-630, 669-672)

40. Applicant's case did not provide any basis for concluding otherwise with respect to the likelihood of erosion. Mr. Steacy while an engineer, was throughout his career engaged in measuring stream flows, and did not involve himself or have occasion to become involved or expert in evaluating or designing projects with respects to the nature and extent of erosion that could be expected from them. (Steacy, Tr. 1127-29)

41. Mr. Steacy made no examination of the characteristics of the banks of the stream other than specific locations near the roads, made no analysis of soil types on the banks, and made no analysis of the sediment characteristics of the Delaware River water or of the colloidal content, although his principal authority, the Fortier and Scobie paper and Brater and King, required establishment of those two factors as the principal variables. (Steacy, Tr. 1244-45; 1248-49)

42. Mr. Steacy did not even consult the soil boring produced by Applicant in connection with the pipeline, nor

ascertain the location of the soil boring in order to evaluate its relevance. (Steacy, Tr. 1279)

43. Mr. Steacy did not consult with any other authorities to determine soil types, or the characteristics of the Delaware River water. (Steacy, Tr. 1279)

44. Mr. Steacy did not consult the original Fortier and Scobie paper, did not make any adjustments as suggested by that paper for bends in the stream, did not determine the definition or characteristics of aging in the stream channel as bases for determining permissible velocity, and did not consider the curves in the stream as a potential bases for increasing velocity at any locations. (Steacy, Tr. 1271, 1249-53, 1264-65

45. Mr. Steacy disagreed, on cross examination with his own authority, the Brater and King text, as to the significance of velocity. (Steacy, Tr. 1260-1262)

46. Mr. Steacy assumed that erosion would not occur at less than bank full stages and therefore did not investigate erosive effects at less than bank full stages. (Steacy, Tr. 1253-54)

47. Mr. Steacy relied on the chapter of Brater and King entitled "Steady Uniform Flow in Open Channels" despite the fact that that chapter stated in the first paragraph that the types of flows discussed therein could only occur in parallel wall channels, thus precluding all natural streams, Mr. Steacy did not consult the chapters at the same treatise entitled "Open Channels with Non-Uniform

Flow" or the "High Velocity Transitions, Including Straight Walled Restrictions, Enlargements in Curved Wall Constrictions and High Velocity Flow at Channel Bends", which were clearly more relevant to the East Branch Perkiomen. (Steacy, Tr. 1249-53)

48. Mr. Steacy did not do any individual cross-sections of the stream bed; rather he relied on one measurement of an estimated average width, derived from pacing a bridge across the stream and looking upstream and downstream from the bridge. (Steacy, Tr. 1281-82)

49. Mr. Steacy's conclusions that there would be little erosion, having failed to account for the foregoing factors, and having failed to consider the actual soil types and the content of the Delaware River water, and being based solely on a one day field survey to update a very rough preliminary 1970 report, and having been developed by a person not experienced in evaluating soil erosion, are entitled to no weight whatsoever.

50. The finding regarding erosion is further confirmed by the fact that the Applicant had originally proposed, as a result of its original very rough analysis in 1970, to channelize the East Branch of the Perkiomen, in order to straighten it out and to provide a stream not so susceptible to erosion. (I-10) The subsequent decision not to channelize was based on the major opposition to channelization which was enunciated by scientists of the Atomic Energy Commission and of such experts as Doctor Ruth Patrick.

However, the decision not to channelize was not supported by any analysis showing that the stream would not erode in the asbsence of channelization. In fact, the proposed scheme will create a defacto channelization of some nature over an extended period of time. (I-20, I-45, I-46; Hershey, Tr. 559-63)

51. Further, the Applicant itself has described, in its Environmental Report to the Nuclear Regulatory Commission, that the diversion would result in doubling the stream width, tripling its depth, and doubling its velocity. While Applicant's witness sought to explain this as referring to changes of wetted area within the existing banks, such description is inconsistent with the language of the Environmental Report which describes scouring of the streambed, increased siltation, channel modification, and bank flooding, and is also incredible in light of the failure of the Applicant to provide, through Mr. Harmon or otherwise, any basis for the conclusions therein. (Harmon, Tr. 982-83; I-46)

52. Harmon admitted on cross-examination that all of his conclusions as to adverse impacts on the East Branch were predicted on the assumption that there would only be short term turbitiy in the stream, and that his conclusions would change substantially if there were long-term turbidity as a result of the diversion, but he could not be specific as to the actual levels or duration of turbidity he expected or would find significant, and stated that his furthest

upstream measurements for turbitity had been taken over 2½ miles below the point of discharge. (Harmon, Tr. 826-282, 847-49, 979-80)

53. Harmon's description of the existing channel width as being approximately 3.1 meters describes the present width of the bank to bank channels, and as being his own description (Table 5-1.26-27 of the EROL), cannot be reconciled with the characterization of the text as referring to changes in the wet area, but must be understood as relating to the channel width referred to in the tables which are referenced in that text. (Harmon, Tr. 982-83)

54. The Applicant's reliance on purported findings of other agencies is unjustified, in that such findings were based on the 1970 Bourquard Report which reported certain predicted velocities at various flows (I-10 at 2-6), but did not evaluate the effects of erosion on such flows and velocities, because it recommended and assumed that there would be a channelized stream. The only subsequent analysis was that performed by Mr. Steacy in 1979, and he merely updated the channel descriptions and calculated velocity and modified them to include consideration of overbank flood flows, but did not re-evaluate the likelihood of erosion, and did not take into account the fact that channelization and therefore channelized and prepared banks were no longer to be assumed. The agency's evaluation both by the DRBC in 1973 and DER 1982, were based on these Bourquard very rough preliminary studies PECo response to comments on draft EIS,

quoting Bourquard as very rough preliminary study)). (I-5; Steacy, Tr. 1129) Neither agency provided any rationale or basis for its apparent assumption that flows below flood flows would not cause erosion, and neither agency provided any rationale, nor did Applicant provide any testimony to support such an assumption, or to contradict or undermine the clear rationale and authorities advanced by the Intervenor.

55. Based on the foregoing, it is clear that there will be substantial long term continuing erosion of the banks of the East Branch of the Perkiomen Creek, resulting in loss of significant property to the downstream riparians on the East Branch. (Hershey, Tr. 572; PHillippe, Tr. 1507)

56. Recognizing this potential effect, the DRBC and the Department of Environmental Resources, in their respective permits, provided that Applicant must take appropriate remedial measures downstream to deal with such effects, but did not specify the nature of those effects, the means by which Philadelphia Electric would be able legally to implement such measures, nor did they provide for compensation or limitations on such effects. (PECo 5d, pg. 8)

57. In these circumstances, it is uncontrovertible, and I so find, that there will be substantial erosion of the banks of the East Branch of the Perkiomen over an extended period of time from enormous increases in the median flow, or stated otherwise in the quantity of water.

58. This substantial erosion will cause damage to riparian rights of downstream owners in the stretch between the discharge point and the Perkasie, a distance of some four to five miles. They will lose substantial acreage, and will also suffer the impacts of continuing erosion. (Hershey, Tr. 487)

59. The continuing erosion will, further, cause continuing turbidity in the stream, which will adversely effect the quality of the water as an aquatic habitat. Independent testimony from the Pennsylvania Fish Commission, provided by Mr. Michael Kaufmann, a fish biologist in Southeastern Pennsylvania Regional Fishery Manager for the Commission, makes its clear that continuing erosion of stream banks will cause a turbidity of the water, which will substantially depress the suitability of the stream as an aquatic habitat. Such testimony is further confirmed by the analysis of Mr. Hershey, and essentially conceded by the testimony of Mr. Harmon, Applicant's witness. (Kaufmann, Tr. 1531-32; Hershey, Tr. 567-69, Harmon, 826-28, 979-80)

60. The diversion will further adversely affect downstream riparians, as demonstrated by Mr. Dornstreich, through deepening the water depth during the summer months, preventing utilization of the stream by small children, and preventing or substantially affecting cross stream access by farmers, of whom several use the stream to get to their fields. Increases in water depth, such as predicted by Applicant's EROL, and confirmed by the Steacy analysis, will

cause substantial adverse economic effect on such farmers. (Dornstreich, Tr. 65-66, 67-68, 88; Hershey, Tr. 487; I-32, Section IV)

61. While the foregoing analysis refers to the impacts of the diversion as proposed for two units, such effects would also be incurred by lesser diversions, although in lesser amounts. (Tourbier, Tr. 327) While construction and operation of one unit at Limerick would reduce such effects, the diversion would continue to have substantial adverse effect, and therefore have similar substantial impacts on the biology of the stream. (Kaufmann, Tr. 1532-33)

C. Flood Effects

62. Additional substantial erosion would be caused by the increased frequency of flood flows exceeding present annual floods, as well as potentially, higher levels at upstream station above Route 313. This would be exacerbated by the fact that the area is subject to flash flood in summer months. (Hershey, Tr. 487-493; Tourbier, 321-22, 325-26; Phillippe, Tr. 1515)

63. While Applicant's diversion would be theoretically limited in times of flooding or high flows in the East Branch, the proposed limitations would not be sufficient to prevent increased frequency of flooding. This will occur because the present limitation, which requires termination of pumping of the diversion only when the flows in the East Branch approach the annual flood conditions (PECo 11 at 42),

do not protect against flood levels which are one half those at the gauging station upstream thereof, and thus permit the diversion to continue when flood flows are occurring at the point of discharge. In addition, there is a major tributary called Morris Run, which enters the East Branch below the gauging station, and a local storm in the subwatershed tributary to Morris Run would not be detected at the gauging station located on Buck Road, thus permitting the diversion to accumulate upon the flood flows of Morris Run without limitation. In addition, the response time to measurement of flooding conditions at Buck Road, assuming a perfect response by the operators of pumping station, and disregarding the potential for slippage because of remote distances and human error, would still incur the likelihood of cumulative flood flows and diversions before effectively terminated. (Hershey, Tr. 485-87; Tourbier, Tr. 324-26)

64. The increase and frequency of the flooding above the one year level would cause higher than normal erosion attributable to the increased median flow described previously, and the cumulative effect of both types of erosion would be highly exacerbated as a result of this condition. (Beemer, Tr. 1415)

65. While reductions in the allowable stream flow (or the trigger for reduction of the diversion) have been discussed, there has been no adoption of any such reduced trigger, and in addition, such reduced trigger would not

necessarily avoid the adverse consequences described. (Harmon, Tr. 989-90)

IV. IMPACTS OF THE PROPOSED FACILITY ON LAND USE

66. The proposed pumphouse will constitute an unsightly industrial type facility in a residential rural area, and will be inconsistEnt with present and proposed use characteristics of the area. (Tourbier, Tr. 328; Hess, Tr. 108-11)

67. The proposed facility would have the following characteristics of an industrial facility, thus incresing its incompatibility with the local area. The exterior of the building would be a conglomerate surface with the appearance of concrete. It would be flat roofed. It would be placed on the edge of the reservoir, requiring the cutting away of trees, with ramps for trucks or other vehicles leading up the side of the 20 foot banks. (Hess, Tr. 104-109; I-4)

68. The building, 15 feet high and constructed on top of a 14 or 15 foot dam or bank, would stand approximately 29 feet above the ground. Moreover, it would be constructed on a high point of land between two watersheds, with the result that it would dominate the landscape. (Hess, Tr. 109)

69. The foregoing testimony was wholly undisputed by the Applicant. Mr. Tourbier is an experienced land planner with extensive experience in central Bucks County, having been employed by the Bucks County Planning Commission and

authored "Techniques for Guiding the Development of Bucks County". Ms. Hess is an experienced realtor and operates extensively in the pumpstead area the local area affected by the pump station. (Tourbier, Tr. 315-16; Hess, Tr. 111)

70. The construction would destroy substantial wooded areas. (Hess, Tr. 108; I-2)

71. In the circumstances, it appears to be clear, and I so find, that the pump station would be incompatible with the characteristics with the local area, both as exist presently, and as planned, and create an unsightly condition which would adversely effect the local area both as to values and as to compatibility with planning and zoning. (Tourbier, Tr. 317; Hess, Tr. 108-09)

72. The proposed use is, of course, inconsistent with the Plumstead Township zoning ordinance and its implicit judgment as to compatible uses.

IV. IMPACT OF FACILITY ON DOWNSTREAM RESIDENTS

73. The Bradshaw pump station, if it or its adjacent dikes failed, would discharge a massive amount of water into the immediate watershed, identified as Geddes Run. The watershed flows down to the Delaware River, and flooding of that stream in the amounts proposed has been such as to classify the dam as hazardous potential for flooding, indicating a potential for loss of property and life. (I-1 at 2)

74. Applicant provided no rebuttal to this testimony.

75. The existence of the pumphouse and its adjacent dikes and the impoundment related thereto, and the classification of such facility will render property in the Geddes Run watershed essentially unsaleable and thereby adversely affect the surrounding community significantly. (Hess, Tr. 112-116, 119)

V. UTILITY OF THE FACILITY FOR RATEPAYERS

76. The proposed facility would cost approximately one hundred million dollars to PECo, assuming the construction of the associated Merrill Creek, and assuming PECo's share of that facility is unchanged. (Phillippe, Tr. 161; I-23; Dickinson, Tr. 302; I-25)

77. These costs assumed that Bucks County would pay a share of construction costs, an assumption no longer true, thus increasing PECo's cost. (I-63)

78. Without Merrill Creek, it is anticipated that the facility would not be operable at least 30 days of each year, and for considerably longer periods in drought years. The utilization of this facility, therefore, will require shutdown or power reduction by the Limerick Generating Station on a frequent basis, in the absence of Merrill Creek.

79. The facility is proposed to be constructed to provide cooling water for two units at Limerick, and the Commission has already found that it is not in the public interest or necessity that PECo presently construct two

units at Limerick, which decision has recently been sustained by the Pennsylvania Supreme Court. (PECo-14)

80. The proposed facility is dependent on the operation of at least three pumping systems, all located remote from Limerick, i.e., the Point Pleasant pumping facility, the Bradshaw pumping facility, and the Perkiomen pumping facility. If Merrill Creek is added, the facility would be depended on four pumping stations. The cumulative potential for failure for these systems, especially in light of their remotness, is a factor to be considered. (Phillippe Tr. 154-5)

81. Cost of delay in water availability beyond Spring, 1985, will be substantial, but completing the proposed system is speculative in light of Bucks County's decision to terminate all contracts. (I-63)

VI. ALTERNATIVES AVAILABLE TO OBVIATE ANY NEED FOR FACILITY

82. The Limerick Generating Station is located adjacent to the Schuylkill River, and it is anticipated that the Schuylkill River water would be used for nonconsumptive cooling purposes at all time, and for the consumptive water makeup purposes during approximately half of each year, depending on flow and temperature in the Schuylkill River. (PECo 5C, p. 1-2)

83. Applicant has not pursued additional water sources in the Schuylkill River for supplying one unit at Limerick. (Dickinson, Tr. 292-98; I-17, I-18, I-19)

84. Several alternatives exist whereby the necessary water for one unit, beyond that presently available, can be provided from within the Schuylkill River Basin. These include the release of supplemental water from Blue Marsh Reservoir to compensate for withdrawal in low flow - high temperature periods in the Schuylkill River, modification of the restrictions on withdrawals from the Schuylkill River flow, possibly combined with a transfer or concession from the City of Philadelphia, of its withdrawal rights from the River, and construction of additional reservoirs in the Schuylkill River Basin. (Phillippe, Tr. 156, 158, 168, 185; I-62)

A. Blue Marsh

85. Blue Marsh Reservoir provides 13,600 acre feet of storage area for water supply, and can be anticipated to provide such volume during the worst drought of record. Of that amount, 8,000 acre feet has been administratively and contractually allocated to water supply purposes, and 6,600 acre feet has been administratively allocated by the Corps of Engineers to "water quality flow augmentation". (Phillippe, Tr. 165)

86. There is adequate water in Blue Marsh Reservoir on a firm and anticipatable basis to provide for one unit at Limerick, even taking into account other existing demands on Blue Marsh Reservoir. (Phillippe, Tr. 1460-67)

87. A conservation release of 41 cfs is normally maintained, and is supplied by the flow of the stream, but has been reduced to 21 cfs during periods of drought warning and drought conditions. (Weston Testimony, pg. 18, Tr. 1151-52; I-53, I-55 December 4, 1980) It is anticipated that this policy may continue. (Weston, Tr. 1152)

88. Assuming the existence of the 8,000 acre feet of water supply storage (or the 14,600 acre feet of total available water in Blue Marsh), and further assuming that the net inflow in the worst drought year of record, after taking into account conservation release, as estimated by Weston, of 1,100 acre feet and further assuming the evaporation in the reservoir of 706 acre feet and further assuming a net loss of 200 cfs for the Western Berks Public Water Supply, and not including consideration of the availablity of the conservation release or any portion of it, the available water from the water supply portion of Blue Marsh alone would substantially exceed the maximum and anticipatible need for supplementally water above the Schuylkill by Philadelphia Electric Company, i.e., 1,500 acre feet. In short, the capacity of Blue Marsh to supply the maximum utilization of one unit at Limerick substantially exceeds the minimum storage available in Blue Marsh. If the augmentation flows are used for that purpose, as is legally possible by administrative action, there would be more than enough water in Blue Marsh to supply two units at Limerick during the worst year of record, or stated otherwise, more

than double the amount needed for one unit. (Weston, Tr. 967-969; Phillippe, Tr. 1461-64)

89. The Delaware River Basin Commission contracted for the water supply storage portion at Blue Marsh, but has not contracted for the water quality flow augmentation portion, and has made no effort to ascertain the availability of such portion for contracting. A study by the Corps will be necessary in order to utilize that, while such study has been recommended, no such study has been performed. (Weston, Tr. 1164-65)

90. The water supply portion of Blue Marsh, 8,000 acre feet, is intended for industrial consumptive use, and as shown in the water plan is supposed to be used for such purpose. (Weston, Testimony p. 21; PECo-22)

91. While it was anticipated that other industrial and municipal users would gradually develop a need for such water over the period to the year 2020, population and water and industrialist water use in the Schuylkill River Basin has fallen substantially below projected amounts, and projections are now substantially lower than they were original analysis was made. (Weston, Tr. 957; I-52; Phillippe, Tr. 156-58)

92. Since the 8,000 acre feet of water supply storage was intended for consumptive use, (Weston, Tr. 954) allocation of such water for consumptive purposes by PECo would not diminish the planned volumes of water in the Schuylkill River, in terms of its availability for flow

augmentation, either in terms of Schuylkill River water flows or in terms of combined flows in the Delaware estuary. (Weston, Tr. 960-61)

93. The water quality flow augmentation capacity of Blue Marsh has not yet been planned for utilization, and has not in fact been utilized for water quality flow augmentation in the Schuylkill River, although it was once used for salinity repulsion in the Delaware estuary. No plans now exist for such utilization, (Goddell, Tr. 1090-91) and projections of Schuylkill River water quality, based on the present water quality treatment standards and projected discharges and flows, shows that no water quality flow augmentation would be required in order to maintain Schuylkill River water quality into the distant future. (Phillippe, Tr. 1467-68)

94. Utilization of this supply by PECo assuming it were to repay the water supply portion of Blue Marsh would cost $25 million for one unit, as compared to the $100 million for the proposed scheme, a savings to the ratepayers of $75 million. For two units, utilization of Blue Marsh would cost $25 million as compared with $100 million for the current proposal, a savings of $75 million to the ratepayers. (Phillippe, Tr. 159-161)

95. Although originally dismissing Blue Marsh utilization, Applicant ultimately produced testimony which conceded that the water is physically adequate to supply one unit at Limerick, considering only the water supply portion of the

storage, although characterized as "marginal" by Applicant's witnesses Weston and Goodell. But the assumptions that these witnesses made in characterizing the water as marginally adequate ignore several relevant factors: (1) they ignore the availability of the conservation release reduction as a drought and drought warning measure, (2) they ignore the utilization of net inflow, and (3) they ignore conservation measures presently purposed for adoption by DRBC calling for a 10% reduction in consumptive use, which would cause PECo's maximum use during severe droughts from 5400 cfs days to 4900 cfs days. Thus using only the figures supplied by Weston and concurred by Goodell, and making just those adjustments, considering only the water supply storage of Blue Marsh and assuming maintenance in present flow restrictions in the Schuylkill River it appears that there is substantially more than adequate water for one unit. (Weston Testimony, p. 20; Goodell Testimony, p. 8-9; Phillippe, Tr. 1458-68)

96. Weston and Goodell also testified that they would consider allocation of substantially of all the water supply capacity of Blue Marsh to one user to be undesirable, and predicted that DRBC would be reluctant to make such an allocation. However, they admitted that the Commission has not been asked to make such an allocation, and further admitted that the Commission is making the Blue Marsh water available for consumptive use to industrial users. (Weston Testimony, p. 22; Goodell Testimony, p. 8; Weston, Tr. 953)

97. Weston's testimony that the utilization of Blue Marsh by Applicant would be inconsistent with potential future irrigation uses is inconsistent with the State Water Plan statement that the projected increases in irrigation uses should not be used as a basis for planning. (Weston Testimony, p. 25; Weston, Tr. 1181; PECo 32 Tables 20, 21)

98. Goodell although chief engineer of the DRBC is not a policy making official, and was not authorized to express the position of the DRBC, and spoke only for himself as an official. (Goodell, Tr. at 107-12) DRBC has not considered use of Blue Marsh for PECo since 1972, and then only for two units. The DRBC director indicated it would reopen its docket if any sponsor might not carry out the project. (I-31) It expressly reserved the right to reopen based on the outcome, inter alia, of the Investigation docket recently affirmed by the Supreme Court. (I-33)

99. Although Goodell testified that he was authorized to provide his testimony by the Executive Director of the Commission, he had no written authorization to do so, and could cite to no rules of the DRBC authorizing him to do so. In addition, Goodell testified that he was authorized to testify by Mr. Weston, who is the chairman member of the DRBC, Mr. Weston testified that he had given no such authority. (Goodell, Tr. 1011-13)

100. While reluctant to provide any water from Blue Marsh to Applicant, both Weston and Goodell indicated that it if necessary to do so, they would concur in permitting up

to 20-25% of the available of the Blue Marsh capacity to be utilized for Limerick. If the total of supplies, including inflow and the water quality augmentation capacity of Blue Marsh were aggregrated, this would supply some 15,000 acre feet, or 7500 cfs days. Twenty-five percent of this amount would be approximately 1800 cfs days, which would equal about 40 percent of the needs of one unit at Limerick in the worst drought year records, assuming maximum consumption throughout that period by Limerick. (Goodell, Tr. 1081-82)

101. There is no reason to suppose that the DRBC or Pennsylvania DER would refuse to provide additional water from Blue Marsh to Limerick in the event that such supply was necessary in order for Limerick to operate, nor is there any reason to suppose that there would be any substantial objection to such sale by any other party, since there is no other present user or potential user for Blue Marsh Reservoir Water. (Western Berks' needs, even if increased as projected, would not be affected, since that is a nonconsumptive withdrawal at the point of the dam, most of which is returned to the river.) (Goodell, Tr. 1082-83, 1099)

102. While Weston testified and Goodell testified that higher consumptive losses, up to 20% of municipal water supply, have occurred in drought times, their testimony does not take into account the DRBC proposal to reduce the types of uses which result in higher consumptive losses, such as lawn watering, during drought periods. In any event, such reductions would not substantially affect the availability

of water downstream, in relation to Applicant needs. (Weston, Tr. 967-68)

103. To the extent that there might be objection to Applicant's consumptive use without compensating storage for salinity repulsion in the Delaware estuary, such compensating storage could be provided by the Merrill Creek Reservoir, as presently planned. Even though the water released from Merrill Creek would not be physically consumed at Limerick, it would replace, and for all functional purposes, the Blue Marsh potential releases for salinity repulsion. In this way, the same storage could be effected, without physically transferring the water from the Delaware River 26 miles to Point Pleasant.

104. In these circumstances, I find no basis by which it can be concluded that the water supply portion of Blue Marsh could not be made available to Applicant without adverse effect on Schuylkill River or Delaware River basin, nor why water quality flow augmentation storage could not be made available to PECo. Thus, Blue Marsh provides adequate water for two units at Limerick, or considering only the water supply portion, provides adequate water for one unit, and obviating the need for the proposed facility.

B. Increased Withdrawals From Schuylkill River Flow; Of Transfer Philadelphia Rights

105. The Applicant is presently limited in its withdrawals from the Schuylkill River by the restriction that it not take consumptive water which would reduce flows in the

Schuylkill River below 530 cfs., and further that it not take consumptive water when the temperature in the Schuylkill River water is more then 59° F. These restrictions limit withdrawals from the Schuylkill River during approximately 50% of the time. (Phillippe, Tr. 1467, 185-89)

106. The 59° limitation was a arbitrary derivation from a 1968 water quality study, which was based on then existing levels of treatment and then anticipated levels of growth and Schuylkill River population and industrial consumption, and continuation of essentially similar uses, and based on such factors, a nonrational derivation of a temperature restriction was deemed relevant to preclude withdrawals during the low flow times in the Schuylkill River during the summer months. (Phillippe, Tr. 190-93; I-6, I-7, I-52)

107. Neither DRBC nor Weston nor Applicant in any other fashion provide any justification or rationale for the temperature limitation, and Weston's testimony assumed it not to be a constraint. (Goodell, Tr. 6-7; Weston Testimony, p. 16-17; Tr. 963-64)

108. Mr. Phillippe made a thorough analysis of the 1968 report which was provided by the DRBC as the basis for the temperature limitation. Mr. Phillippe has extensive experience in the field of water quality analysis and modeling of water quality conditions in relationship to uses and discharges of water, and carefully studied a thorough report on the Schuylkill River water quality conditions and projected conditions performed by DER and completed in 1977 in

accordance with present techniques and present policies, which determined that through the year 2000, adequate water quality conditions can be maintained in the Schuylkill River with projected uses and treatment at flows substantially less than 500 cfs, and with temperatures of up to 82° F. (Phillippe, Tr. 189-98)

109. No other user of Schuylkill River water has been constrained by any such temperature limitation, and no such temperature limitation is imposed on Applicant's withdrawals from the Perkiomen Creek for the project, although Perkiomen Creek water flows into the Schulykill River. (Phillippe, Tr. 189)

110. In these circumstances, it is unnecessary to consider the temperature limitation as a constraint, because of Weston's testimony and Phillippe's testimony, it is obvious that such limitation would no longer be imposed if Schuylkill utilization would be newly considered by DRBC.

111. With regard to minimum flows in the Schuylkill River, the 500 cfs minimum (after PECo's assumed withdrawals for 30 cfs for one unit or 60 cfs for two units) is similarly no longer relevant or necessary for water quality purposes in the Schulykill River or for any other purposes. (Weston, Tr. 960-61; Phillippe, Tr. 1466-68)

112. While Schulykill River water is subject to reuse, such reuse is nonconsumptive, and is not dependent on any flow higher than Q7-10 flow of 230 cfs. (Phillippe, Tr. 1469)

113. Although there are major industrial users of Schuylkill River water, such uses are mostly nonconsumptive, and the largest of such uses, both consumptive and noncomsumptive, constituting more than 70% of the total occur below the Fairmont Dam, where the Schulykill River is a part of the Delaware estuary, and not truly the Schulykill River. (Phillippe, Tr. 1471)

114. Although Weston testified that the Schuylkill River is heavily reused, most of the use of the Schuylkill River occurs below the Fairmont Dam, and is not in fact, a use of the Schuylkill River at all, but rather of the Delaware estuary. (Phillippe, Tr. 1471)

115. The only remaining basis on which to require that Schulykill River water maintain above the Q7-10 value, which is the normal minimum flow value utilized for stream flow maintenance in Pennsylvania and elsewhere, is for protection of aquatic life.

116. As indicated in the paper utilized by Weston, fishery agencies consider it satisfactory on satisfactory streams, of which the Schuylkill is normally classified, to maintain 15% of the average daily flow. (Weston Exhibit H at 10) The average daily flow in the Schuylkill River is 1821 cfs, and 15% of that would be 273 cfs. (Phillippe, Tr. 1460-61) Based on these values, as indicted in the Weston testimony (Weston Exhibit L), the Schuylkill River would have a flow of more than 273 cfs 85% of the time, thus necessitating the use of Blue Marsh or other supplemental

storage only 15% of the time, rather than 50% assumed in the present calculations, based on the flow maintenance requirement of 500 cfs for consumptive utilization. (Phillippe, Tr. 1460-61)

117. Utilization of supplemental storage would for 15% of the time equal approximately 55 days, or approximately 1800 cfs days in the worst drought year record, less 10% conservation recommended by DRBC or up to 500 cfs days, i.e., 1300 cfs days, not dissimilar from the 1,000 cfs days which Messrs. Weston and Goodell would be the maximum they would approve, and even obviously much further below the total available capacity of Blue Marsh or even 25% of the water supply capacity of Blue Marsh including inflow and both the water supply capacity and the flow augmentation capacity a total of approximately 9,000 cfs days, (rather than the 4,000 cfs days attributed by Mr. Weston, which excluded inflow).

118. Neither the DRBC nor DER nor PECo has sought information from the fishery agencies as to the minimum flow which they would accept on the Schuylkill River in order to avoid implementation of the proposed project, which they oppose because of its substantial adverse effect on the Delaware River. (Weston, Tr. 1207)

119. At the direction of the Commission, inquiry has been made of the fishery agencies to determine their answer to this question, but response have not yet been received. (Weston, Tr. 1208)

120. The largest water user below Limerick and above the Fairmont Dam, is the City of Philadelphia, which has an allocation to 268 million mgd. in the Schuylkill River. Philadelphia has indicated its willingness to make arrangements or concessions so as to avoid the use of 23 mgd of the entitlement, thereby by obviating the potential problems related to one major user. (Marrazzo, Tr. 387-89; I-32)

121. Such an arrangement with the City of Philadelphia and modifications in the minimum flow and temperature restrictions in the Schuylkill River has not been considered by the Applicant. (Boyer, Tr. 760; Marrazzo, Tr. 389)

122. Based on his review of his the fishery requirements and the water quality requirements and other user requirements in the Schuylkill River, Mr. Phillippe concluded that the reductions of the minimum flow restriction in the Schuylkill River substantially below the present 500 cfs., combined with offset storage would be a viable solution for PECo which would not adversely affect the Schuylkill River. (Phillippe, Tr. 1467-68)

123. Mr. Weston, not a water quality expert nor an engineer, expressed concern as water manager regarding the impacts of flow reduction, but related these to such matters as fishery management, without discussing the matter with fishery agencies, water reusers, without considering the fact that most of the water reuses is in the estuary, and general fears and concerns, unsupported by any expert analysis or reports. Mr. Weston is a policy manager, and an

advisor to the Governor of Pennsylvania, and his conclusions are on the one hand not definitive with respect to the policy position either of the Department of Environmental Resources, which is represented by its Secretary, nor the Governor as a member of the DRBC, to whom Mr. Weston is an advisor. (Weston, Tr. 913, 916-22, 937-39, 941)

124. Mr. Goodell was not able to provide any expert testimony as to any adverse impacts of reducing flow limitations or limiting the temperature limitation on the consumptive use of the Schuylkill River water by the Applicant. (Goodell Testimony, p. 7-8)

125. While both Weston and Goodell contested the legal rights of the City of Philadelphia to make a transfer of its entitlement to Applicant, neither of them provided any basis for ignoring the relevance of the City's position, and in fact Mr. Weston conceded that the City might be able to provide waiver or release of any claims that it might have, which would be relevant to PECo's upstream use in terms of the rights of downstream riparians. (Goodell Testimony, p. 7; Weston Tr. 1203)

126. Mr. Weston had previously expressed the view that the PECo use for Limerick would not likely be approved if a new matter in today's conditions, because of its adverse effects on the Delaware River estuary and because of its adverse effects on the Delaware River. Thus, any proposed modifications on the Schuylkill River conditions would have to be considered by Mr. Weston in light of the

undesirability of the present proposed project as well as its potential adverse effects on the Schuylkill River, if any; in other words, to choose the lesser of undesirable conditions. (I-54)

C. Reduction In Size Of Limerick As An Alternative

127. Although no record has been made, nor proposed in this proceeding regarding the need for Limerick Unit 2, as approved by the Supreme Court in Pennsylvania PUC v Philadelphia Electric Company et al., No. 23 E.D. Appeal Docket 1983 (May 27, 1983), this Commission may consider evidence adduced in the investigation docket and the utility rate increase dockets as indicated in that appeal. Therein, it has been found the PECo's construction of Limerick Unit 2 at least at the present time is not in the public interest. Thus, it is necessary to consider only one water for only one unit at Limerick.

128. However, should it be considered that water was needed for two units at Limerick, there are ample opportunities for consideration and implementation of alternative projects on the Schuylkill River.

129. In light of the physical adequacy of Blue Marsh Reservoir unallocated supply to provide for one unit at Limerick, and the absence of rational justification for the present flow restrictions in the Schuylkill River, and the potential for making such water available to the Applicant, and given the unexamined potential for converting the flow

augmentation storage capacity of Blue Marsh to water supply capacity, and the adequacy of such capacity, together with a reduction of restriction in the Schuylkill River, and given the role of rational water management planning in allocating such water, and setting such restrictions, and given the further economic interest of the Commonwealth in minimizing both the environmental effects and the economic cost of providing necessary cooling water for Limerick, all the evidence supports only the conclusion that there is physically available in the Schuylkill River with existing facilities, and specifically Blue Marsh Reservior, more than adequate supply for two units at Limerick in the worst year of record, assuming maximum consumption. (Phillippe, Tr. 1458-68)

130. While Weston and Goodell have indicated opposition to dedication of more than 25% of Blue Marsh to Philadelphia Electric Company, there is no evidence that there are any other present users presently desiring such capacity. In these circumstances the entire available capacity in Blue Marsh can be safely allocated to Applicant, and the relevant agencies, including DER and DRBC, can select from a wide range of alternatives previously identified as feasible to provide for additional capacity as needed for any additional growth that might occur.

131. Such additional feasible alternatives, conversely, are available for utilization to accommodate a second unit at Limerick, in the event that one is ever built.

132. These feasible alternatives, identified by PECo and industry consultants, include a reservoir on Red Creek, which would be supported by U.S. Fish and Wildlife Service, and would assist in water quality maintenance, insofar as clean spring water run-off was used to fill it; as well as numerous local reservoirs in the vicinity of Limerick, identified by the Tibbits, Abbot, McCarthy Stratton Study (May, 1973). (Phillippe, Tr. 1472-78; I-62, I-12, I-13; "Exhibit 6")

133. In the event that unit 2 is ever completed, PECo can also utilize dry cooling towers, a technology which has been improved since last considered in 1975 by DRBC for Limerick. Dry cooling towers would obviate the need for most or all of the consumptive cooling water for which Applicant is proposing the present facility. Although energy requirements for such facilities are substantial, they may be more economically feasible in the future because of the excess energy capabilities in the PECo and PJM systems identified in the Limerick investigation.

VI. SUMMARY

134. The substantial environmental harms resulting from construction of the pumphouse, including adverse effect on the surrounding rural/residential area with its highly visible unsightly appearance, and massive erosive effects and downstream flooding on the East Branch Perkiomen resulting from pumpage of the cooling water to Limerick, would

clearly outweigh the benefits to be derived from the project, particularly in view of the availability of cost-effective water supplies in the Schulykill River Basin.

135. In failing to seriously consider available cost-effective alternatives to the transport of water from Point Pleasant, thus avoiding the serious adverse impacts on the East Branch Perkiomen and other effects, the Applicant has failed to demonstrate a reasonable effort to reduce environmental incursion to a minimum.

136. In the circumstances, the evidence is clear and convincing that the proposed facility is not reasonably necessary in light of the substantial economic effect that it will have on the surrounding community, and that the purposes sought to be achieved by the utilization of the facility, i.e., providing cooling water to the Limerick Generating Station, can be achieved by measures which would not have the significant effects which would occur as a result of the utilization of the proposed facility.

Respectfully submitted,

ROBERT J. SUGARMAN
Counsel for Intervenors

Of Counsel

SUGARMAN & DENWORTH
121 S. Broad Street
Suite 510
Philadelphia, PA 19107
(215) 546-0162

Dated: June 10, 1983
051

RECEIVED
JUL 05 1983
SUGARMAN AND DENWORTH

Position Paper on
Proposed Amendments to Comprehensive Plan
to Revise the Descriptions of the Tocks Island,
Francis E. Walter, Prompton, and Cannonsville Projects

Tocks Island Project

From the early 1920s until the Delaware Valley flood disaster of 1955, various plans were considered to augment the region's water supply storage by constructing a main stem dam in the vicinity of the Delaware Water Gap. Although some thought was given to incorporating a conventional hydropower facility to produce some energy, the main stem dam proposals during this early period lacked major flood control and recreation features and were not multi-purpose in today's context. A plan promoted by the Interstate Commission on the Delaware River Basin (INCODEL) to build a large main stem water supply dam at Walpack Bend, a short distance upstream of the Water Gap, fell just short of approval in the early 1950s in a close Pennsylvania Senate vote. In August of 1955, the Delaware main stem and upper tributaries were stricken by the worst flood event experienced to date following back-to-back hurricanes, Connie and Diane, less than a week apart. The death toll was 99 persons, all on tributaries, and damage exceeded $100 million (1955 prices), more than a quarter of it on the main stem below the Water Gap. The municipalities of Belvidere, Easton, Phillipsburg, Frenchtown, New Hope, Lambertville, Yardley, Trenton, Burlington, and Bordentown were among the damage centers. As a result, Congress directed the U. S. Army Corps of Engineers to make an extensive survey of the basin's needs.

In 1960, the Corps' Report on the Comprehensive Survey of the Water Resources of the Delaware River Basin[1/] was completed and recommended a series of federal and state reservoir projects, keystone of which was the 12,000-acre multi-purpose lake behind a dam located five miles upstream of the Water Gap at Tocks Island. The lake was seen also as the central feature of a 60,000-acre National Recreation Area. In 1961, the region's four Governors, as members of the new Delaware River Basin Commission (DRBC), threw full support to the proposed Tocks Island project and other features of the Corps' report. In 1962, the Basin Commission's Comprehensive Plan for the region's water future was adopted with Tocks Island, including the National Recreation Area, its key component. DRBC action was followed by Congressional authorization of Tocks Island (but not the National Recreation Area), and seven companion reservoir projects which included the modifications to the Prompton and Francis E. Walter (then known as Bear Creek) projects. In 1963, Congress appropriated the initial funds for the Corps to begin post-authorization design of Tocks Island.

In 1965 the basin's worst drought reached its most intense level as ocean salts, moving up-river, threatened to contaminate fresh water supplies in the Philadelphia-Camden metropolitan area. In the absence of adequate storage, DRBC imposed emergency measures and enacted formulae

1/ printed as HD 522, 87th Cong. 2nd Sess.

assuring equitable sharing of available water supplies between New York City's upper Delaware reservoir system and the downstream states.

In 1974, as urged by the DRBC, Congress ordered the Corps of Engineers to make a one-year comprehensive re-study of the entire Tocks Island project. This re-study concluded that technically viable water supply alternatives to the Tocks project existed, but that the relative cost, benefit, and environmental impacts of these alternatives needed to be resolved.

On July 31, 1975 the DRBC Governors, in a 3 to 1 vote, recommended that Congress not fund a Tocks Island project construction start. No position was taken on whether this project should be deauthorized, and it remains today as an authorized project.

In 1976, the U. S. Water Resources Council funded the Delaware River Basin Comprehensive (Level B) Study to review the entire Comprehensive Plan, including present and projected demands for water within the Basin, a comparison of those demands with available water supply, and the development of appropriate measures to keep the supply and demand in balance.

Late in 1978, Congress incorporated into the National Wild, Scenic and Recreational Rivers System the 38-mile Middle Delaware that is the Pennsylvania-New Jersey boundary in the Delaware Water Gap National Recreation Area (the reach of the river that would form the Tocks Island impoundment). The river was designated as scenic from Milford to Shawnee and as recreational from there to the Water Gap.

Because hydrologic and storage conditions in the Delaware River Basin changed substantially over the more than two decades after the U. S. Supreme Court Decree of 1954, late in 1978, DRBC called upon the parties to the Decree "to enter into serious good faith discussions to establish the arrangements, procedures, and criteria for management of the waters of the Delaware Basin consistent with the Compact." The drought emergency of the mid-1960s and the decision of 1975 not to proceed at that time with construction of the Tocks Island dam were major background events giving rise to the Commission action.

In 1981, the Final Report and Environmental Impact Statement of the Level B Study was completed. The report analyzed current and projected conditions on supply and demand and set forth certain proposals for modifying the Commission's Comprehensive Plan. During the study, all of the projects that had been identified in the URS/Madigan-Praeger Tocks Island report 2/ as possible alternatives to Tocks Island were restudied, as well as a review of the projects already included in the DRBC Comprehensive Plan. The Final Level B Report offered a Preferred Plan which included those policies and physical features of the Comprehensive Plan which were found to be in need of a change.

2/ Comprehensive Study of the Tocks Island Lake Project and Alternatives - URS/Madigan - Praeger, Inc./Conklin & Rossant, - July 1975.

Under the heading of Water Storage Projects, the Level B Preferred Plan provided that the environmental aspects of the Francis E. Walter project modification, the Prompton project modification, the Cannonsville project modification, the Hackettstown project and the Merrill Creek project should be thoroughly investigated and, if found acceptable, that construction of said projects should be expedited. Also, the Aquashicola, Evansburg, Newark, Tocks Island, and Trexler projects should be retained in the Comprehensive Plan for possible development after year 2000.

The "Good Faith" negotiations progressed, using information and data provided by the Level B Study, including a new, more comprehensive salinity model of the estuary that had been utilized for the Final Level B effort. The negotiators also gained valuable experience and greater insight into drought-operating capabilities during the 1980-1981 drought. The "Good Faith" negotiations concluded in February 1983 with publication of the report entitled Interstate Water Management Recommendations of the Parties to the U. S. Supreme Court Decree of 1954 to the Delaware River Basin Commission Pursuant to Commission Resolution 78-20. That document incorporates many recommendations contained in the 1981 Level B Study Report. Ten of the fourteen "Good Faith" recommendations are identical to Level B Study Report recommendations, and the other four are Level B elements slightly modified to reflect experience and information gained during the drought of 1980-1981. The five parties agreed upon enlargement by the federal government of the existing Francis E. Walter reservoir in the Lehigh valley by the end of 1990 and Prompton reservoir in the Lackawaxen valley by the end of 1995. Both are in Pennsylvania. New York City's Cannonsville reservoir in Delaware County, New York, is to be enlarged, if determined to be practicable by feasibility and environmental studies, by New York State by 1990, and a proposed power company impoundment on the site of a smaller reservoir on Merrill Creek in Warren County, New Jersey, is endorsed for completion by the end of 1986, if found environmentally feasible.

The long-planned Hackettstown reservoir on the Musconetcong River in northwestern New Jersey was eliminated from consideration after being dropped from that state's water supply master plan in 1981 due to poor subsurface conditions. The state is seeking an alternative source.

Regarding Tocks Island, Recommendation 9 in the "Good Faith" report provides: "The parties are agreed that the proposed Tocks Island project should be held in reserve status for development after the year 2000 if needed for water supply. The Commission should amend its Comprehensive Plan by adding an updated description of the Tocks Island project."

Francis E. Walter and Prompton Projects

The modifications of the Francis E. Walter and Prompton projects, existing single-purpose Corps of Engineers flood control projects, were incorporated into the DRBC Comprehensive Plan in 1962. These projects were reviewed in the Level B Study, which recommended that construction be expedited for both, if found environmentally acceptable.

Experience of recent droughts has underscored the need for increased water storage, water supply and flow augmentation capacity in the Delaware Basin. The Basin is even now in a deficit condition in terms of flow required to meet the year 2000 salinity control objective proposed in Recommendation 1 of the "Good Faith" Report, even though the proposed interim standard of 180 mg/l chlorides could be met at this point in time. New augmentation facilities are needed to provide for modest growth and achievement of the 150 ppm chloride standard by the year 2000. The conservation measures proposed in Recommendations 10, 11, and 12 of the "Good Faith" Report will be an important drought management tool and will partly offset increasing use, but will not suffice alone.

With recurrence today of a drought equal in severity to that of the 1960s, system operation of the basin's existing impoundments could maintain a flow at Trenton of about 2,500 cfs, including the effects of the proposed reduced diversions, flow objectives at Montague, and conservation recommended by the parties. Under the impact of increased depletive use, as projected in the Level B Study, that capability will drop to slightly less than 2,300 cfs by the year 2000 if no new flow augmentation of water supply sources are developed before that date.

These levels of capability contrast sharply with the estimated 2,900 cfs that will be needed to meet the stricter year 2000 salinity objective under projected conditions 17 years hence. Even with allowance for the approximations inherent in these numbers, the conclusion is inescapable that the existing water storage, water supply and flow augmentation facilities in the basin are insufficient to cope with the impact of drought by the year 2000. Measured against the year 2000 salinity objective (150 mg/l of chloride at River Mile 98) the present shortfall is about 50 cfs. However, currently (1983) the Trenton flow-capability is about 110 cfs greater than that required to meet the interim salinity objective (180 mg/l of chloride at River Mile 98). If depletive water uses increase as projected, and no new facilities are developed, this shortfall would increase to about 600 cfs by the year 2000, even with the imposition of rigorous water conservation measures. Recommendation 5 in the "Good Faith" Report provides that the Parties agree to endorse and promote modifications of Walter and Prompton projects for water supply and flow augmentation for salinity control.

The modifications to both the Walter and Prompton projects would involve converting the existing single purpose flood control projects (with incidental recreation) to multi-purpose projects for flood control, water supply, low flow augmentation for water quality control and for recreation. The existing authorized flood control storage in each project would be preserved at both projects.

Comparative data on the present and proposed modified project (preliminary) at each site are as follows:

Francis E. Walter Project

	Present Project	Proposed Modified Project
Capacities, in acre-feet		
Flood Control	108,700	108,700
Water Supply & Low Flow Aug.	0	69,500
Inactive	2,000	2,000
Elevation, Top of Pool (msl)		
Flood Control	1,450	1,481
Water Supply & Low Flow Aug.	0	1,425
Inactive	1,300	1,300

Prompton Project

	Present Project	Proposed Modified Project
Capacities, in acre-feet		
Flood Control	48,500 1/	20,300
Water Supply & Low Flow Aug.	0	30,900
Inactive	3,500	800
Elevation, Top of Pool (msl)		
Flood Control	1205.0	1205.0
Water Supply & Low Flow Aug.	0	1180.0
Inactive	1125.0	1112.0

1/ 20,300 acre-feet of storage for reservoir design flood (elev. 1168.1); 28,200 acre-feet of additional storage to spillway crest.

With regard to the flood control storage in the Prompton Project, the Reservoir Design Flood, which is defined by the Corps of Engineers as the maximum flood that can be completely contained by a reservoir, was determined by the Corps, and when routed through reservoir storage, required 20,300 acre-feet of flood control storage at Prompton. This amount of flood control storage then was the economically justified storage upon which the downstream flood control benefits were based. The magnitude of the Reservoir Design Flood is several times greater than any flood ever actually experienced at the site and has a return frequency of greater than 100 years. However, due to the physical features of the dam site, the dam was constructed higher than would normally be required since it proved more economical to raise the dam than to construct an expensive spillway at a lower elevation. As a result, 28,200 acre-feet of additional storage, in addition to the 20,300 acre-feet required for flood control, was provided in the Prompton project.

Also, the Corps of Engineers, during the initial post-authorization studies in 1968[1], concluded as follows:

> "Additional flood control storage in Prompton Reservoir above that now authorized (20,300 acre-feet equal to 6.4 inches of runoff) for downstream protection is considered unwarranted for the following reasons:
>
> (1) The major damage center of Honesdale is only a short distance downstream and the combined effect of the Prompton and Jadwin projects will eliminate all flood damages in this area except for very infrequent floods such as those having peak flows in excess of 100-year recurrent events.
>
> (2) Even if damaging flows should occur as a result of uncontrolled flow downstream of Prompton Reservoir, the releases from the reservoir could be kept to a minimum so as not to aggravate or increase the flood conditions."

These prior conclusions will, of course, be reviewed by the Corps during the forthcoming environmental and updated detailed design studies. The Corps will prepare the necessary Environmental Impact Statements for both the Francis E. Walter and Prompton projects.

The following table shows the maximum elevation of the flood control pool, the maximum amount of flood control storage used, and the percentage of the authorized flood control storage (20,300 acre-feet) used during each of the 23+ years that Prompton has been in operation. As indicated, the maximum percentage of the 20,300 acre-feet of flood control storage used in any year to date was 23.2 percent in year 1973.

1/ Prompton Reservoir, Lackawaxen River, Pa., Design Memorandum No. 11, General Design Memorandum, U.S. Army Engineers District, Philadelphia - February 1968.

Utilization of the Authorized
Flood Control Storage (20,300 acre-ft) in Prompton Project

Year	Elevation of Annual Maximum Flood Control Pool (ft - msl)	Flood Control Storage Used (acre-feet)	Percent of Authorized Flood Control Storage Used
1960	1128.0	840	4.1
1	1131.19	1900	9.4
2	1131.08	1854	9.1
3	1131.85	2177	10.7
4	1133.45	2849	14.0
5	1127.93	820	4.0
6	1128.58	1002	4.9
7	1130.40	1568	7.7
8	1129.65	1302	6.4
9	1131.30	1946	9.6
1970	1130.80	1736	8.6
1	1130.18	1476	7.3
2	1133.02	2668	13.1
3	1138.54	4704	23.2
4	1131.56	2055	10.1
5	1132.80	2576	12.7
6	1131.01	1824	9.0
7	1133.04	2677	13.2
8	1130.23	1497	7.4
9	1133.07	2689	13.2
1980	1129.48	1254	6.2
1 1/	1137.98	4513	22.2
2 1/	1137.93	4496	22.1
3 2/	1130.10	1442	7.1

1/ on top of emergency drought water supply pool at elev. 1135

2/ through April 16.

It is also important to note that releases from a modified Prompton project will not reduce the amount of releases required by New York City to meet the Montague formula.

Cannonsville Project

The Cannonsville Reservoir was added to the Comprehensive Plan in Addendum No. 1, adopted July 25, 1962. Modification of Cannonsville was proposed in the report of the Temporary State Commission on the Water Supply Needs of Southeastern New York, December 1973, and recommended in the Level B report. The reservoir level would be increased approximately eight feet by the addition of flashboards or gates on the spillway. This would increase storage by approximately 13.1 billion gallons.

Recommendation 6 in the "Good Faith" Report provides that the State of New York enlarge the Cannonsville Reservoir in Delaware County, New York, if determined to be practicable by feasibility and environmental studies. Subject to the outcome of these studies, construction should be completed by 1990. The requirements of Section IIIB of the U. S. Supreme Court Decree of 1954 relating to excess releases should be waived as to the additional storage included in the Cannonsville modification project. Additional project yield should be used primarily to maintain conservation releases. Secondary purposes should be to support the Montague flow objectives and diversions to New York City within the limits of the 1954 U.S. Supreme Court Decree. Pre-construction studies of the Cannonsville modification might also lead to improved release works relative to the conservation release program.

Specifically, it is proposed to:

Amend the Comprehensive Plan as follows:

1. Delete in its entirety, the description of the Bear Creek Project (later renamed Francis E. Walter) on pages 13, 14, and 15, and insert, in lieu thereof, the description of the Francis E. Walter Project in Appendix A.

2. Delete in its entirety, the description of the Prompton Project on pages 8 and 9 and insert, in lieu thereof, the description in Appendix B.

3. Delete in its entirety, the description of the Cannonsville Reservoir contained in Addendum No. 1 to the Comprehensive Plan—Phase I, adoted July 25, 1962, and insert, in lieu thereof, the description in Appendix C.

4. Delete in its entirety, the description of the Tocks Island Project on pages 9, 10, and 11 and insert, in lieu thereof, the description in Appendix D.

These amendments shall take effect immediately.

Appendix A - Proposed Revised Comprehensive Plan Description of Francis E. Walter Project

Appendix B - Proposed Revised Comprehensive Plan Description of Prompton Project

Appendix C - Proposed Revised Comprehensive Plan Description of Cannonsville Project

Appendix D - Proposed Revised Comprehensive Plan Description of Tocks Island

These appendices are included in the attached Delaware River Basin Commission's Notice of Public Hearings of July 1, 1983.

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
One Gateway Center, Suite 700
NEWTON CORNER, MASSACHUSETTS 02158

JUL 20 1983

Mr. R. Timothy Weston
Deputy Assistant Secretary
Pennsylvania Department of
Environmental Resources
P.O. Box 1467
Harrisburg, Pennsylvania 17120

Dear Mr. Weston:

This responds to your June 1, 1983, letter to Director Jantzen requesting the Service's comments on three alternatives to supply water to the Limerick Nuclear Generating Station, Chester and Montgomery Counties, Pennsylvania.

Alternative 1 (reduction of Schuylkill River flows/use of Blue Marsh storage).

DRBC Docket No. 69-310 CP placed two restrictions on water withdrawn from the Schuylkill River at Limerick: a) flows at the Pottstown gage must exceed 530 cfs with one unit operating and 560 cfs with two units operating; and b) there must be no withdrawals when water temperatures below Limerick exceed 15°C, except during April, May, and June when the flows as measured at the Pottstown gage exceed 1,791 cfs.

Use of this alternative would not require relaxation of the 530/560 cfs flow restriction established by the DRBC. It would require only that attention be given to identifying and utilizing the potential for storing sufficient makeup water in Blue Marsh Reservoir (see discussion of Blue Marsh under Alternative 2). Given a recurrence of the 1965 drought, approximately 8,000 acre-feet of stored water would be required to meet DRBC's flow restriction of 530 cfs with one unit operating at maximum output. There are 8,000 acre-feet of storage currently in Blue Marsh Reservoir for industrial and municipal use and another 6,600 acre-feet for water quality control downstream. We believe that the Philadelphia Electric Company could operate Unit 1 using the Blue Marsh Reservoir as an interim source of make-up water until environmentally-sound storage facilities could be developed. Initiation of operation of Unit 2 and continued long-term operation of Unit 1 should be contingent upon either expanding existing storage reservoirs or developing new sources of storage in the Schuylkill drainage. In any event, we do not recommend that the required flows of 530 and 560 cfs be reduced in any alternative plan.

We believe that the second restriction could be relaxed without degrading water quality downstream. The restriction was originally designed to protect water quality and fishery resources and appears somewhat conservative in light of results of the 1976 COWAMP Study for the Schuylkill River. For example, the water quality model developed for the study predicted very few violations of State standards for dissolved oxygen in the Philadelphia area at a flow of 290 cfs and a water temperature of 29°C. The study also predicted that water quality would improve in the future as more sewage treatment plants were upgraded. The Department of the Interior's 1968 Water Quality Control Study for Blue Marsh Reservoir made similar observations, indicating that dissolved oxygen levels in the lower Schuylkill River did not drop below 4.0 mg/l until flows were less than 300 cfs. Any proposal or plan to relax the second constraint on withdrawal should be based upon a thorough investigation of the relationship between consumptive withdrawals at Limerick and resultant water quality alterations downstream, particularly those involving water temperature and dissolved oxygen.

Alternative 2 (Construction of the Red Creek Reservoir).

In letters dated February 23, 1973, and June 25, 1974, the Department of the Interior recommended the Licensee consider make-up water storage sites in the Schuylkill River Basin. More recently, the Department's October 25, 1982, letter on the draft Environmental Impact Statement for the Merrill Creek Reservoir Project recommended the re-evaluation of storage reservoirs on the Schuylkill River as less environmentally damaging than the Merrill Creek site. During the screening of alternative sites for the Limerick Nuclear Generating Station make-up water source, the Red Creek site was eliminated primarily because of poor water quality and the Blue Marsh site because it would not be completed in time. However, delays in constructing the Limerick Nuclear Generating Station have changed the status of these two sites.

Because of reduced mining effort and the success of reclamation projects upstream of the Red Creek site, water quality in the Schuylkill River has significantly improved in the past six years. The Red Creek site could now withdraw reasonably good quality water from the Schuylkill River with ph in the range of 6-7 units. We now believe that water quality in a reservoir on Red Creek would support a good warmwater fishery. Furthermore, discharges from the reservoir would benefit aquatic organisms in the Schuylkill River during low flow periods. Therefore, the Red Creek site appears well suited for fulfilling the need for additional storage in the Schuylkill River Basin (although perhaps not uniquely so).

The Blue Marsh Reservoir is now completed and operational. The necessary additional make-up water storage capacity for the Limerick Nuclear Generating Station could be made available by raising the pool level in the Blue Marsh Reservoir 6 feet for one unit and 9 feet for two units. This would permanently flood an additional 300 and 450 acres of land, respectively. Either alternative reservoir site on the Schuylkill River would eliminate the need for building the Point Pleasant Diversion project, Bradshaw Reservoir, and possibly the Merrill Creek Reservoir. Sites on the Schuylkill River would benefit water quality by providing additional flows during low water in the river.

<u>Alternative 3</u> [Bradshaw Reservoir/Bradshaw Pump Station (Point Pleasant)].

The Service has advised against constructing the Point Pleasant Diversion project for numerous reasons. Our March 11, 1980, and December 16, 1980, letters to the DRBC identified and discussed at least 12 specific adverse environmental impacts that could result from constructing and operating the Point Pleasant project. Our letters of June 19, 1981, and March 26, July 12, and September 14, 1982, to the Corps of Engineers presented additional reservations about the proposed project. We summarized our concerns again in our letter of October 18, 1982, which recommended denial of the Department of the Army permit for the project. Throughout all of our communication with DRBC and the Corps, we maintained that there were environmentally preferrable alternatives to the Point Pleasant project.

In summary, from a fisheries conservation and management perspective, of the three alternatives that you proposed we would prefer Alternative 2.

If we can be of further assistance, please do not hesitate to ask.

Sincerely yours,

Howard N. Larsen

Regional Director

DISTRIBUTION:
Docket File (50-352/353)
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IE (3)

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TERA
NSIC
TIC

Mr. Gerald M. Hansler
Executive Director
Delaware River Basin Commission
P. O. Box 7360
West Trenton, New Jersey 08628

Dear Mr. Hansler:

This is in response to your letter of December 15, 1980 to Mr. Darrell Eisenhut concerning the preparation of an environmental impact statement for the Limerick Generating Station (LGS) during the NRC's operating license review.

As indicated in recent conversations, the Nuclear Regulatory Commission will review the environmental impacts associated with the operation of the LGS, including those facilities that are required to support its operation. This review will specifically consider information and data that has been developed subsequent to the issuance of our Final Environmental Statement for the construction permit. After completion of this review both draft and final environmental statements will be issued.

Sincerely,

Robert L. Tedesco
Assistant Director for Licensing
Division of Licensing

LB #2/DL	LB #2/DL	A/D:L:DL
DSells/LLM	ASchwencer	RLTedesco
12/16/80	12/16/80	12/ /80

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

JUL 15 1983

IN REPLY REFER TO
Environmental Resources Branch

Director, Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Sir:

This letter is in response to your agency's request of June 24, 1983 for comment on the Draft Environmental Impact Statement related to the operation of Limerick Generating Station, Units 1 and 2 located on the Schuylkill River near Pottstown, Montgomery County, Pennsylvania.

We concur with NRC staff's conclusions that:

a. that there would be no detectable effects to the Delaware River resulting from the Point Pleasant Pumping Station;

b. that the Point Pleasant Pumping Station will have no significant impacts on the sites listed or eligible for listing in the National Register of Historic Places;

c. that there will be no significant impact to any life stage of the endangered shortnose sturgeon.

Thank you for the opportunity to comment on the Draft Environmental Impact Statement. Please continue to keep this office informed as to the status of the project. If you have any questions regarding these comments, please contact Mr. Roy E. Denmark, Jr., Acting Chief, Environmental Resources Branch at (Area Code 215) 597-4833.

Sincerely,

Nicholas J. Barbieri, P.E.
Chief, Planning/Engineering Division

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PDR ADOCK 05000352
D PDR

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Washington, D.C. 20230

OFFICE OF THE ADMINISTRATOR

AUG 29 1983

Director, Division of Licensing
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Sir:

Enclosed are comments from the National Oceanic and Atmospheric Administration on your draft environmental impact statement related to the operation of the Limerick Generating Station, Units 1 and 2, Docket Nos. 50-352/353.

Thank you for giving us an opportunity to provide these comments, which we hope will be of assistance to you. We would appreciate receiving two copies of the final environmental impact statement.

Sincerely,

Joyce Wood

Joyce M. Wood
Chief
Ecology and Conservation Division

Enclosure

C002
1/1

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
Washington, D.C. 20230

N/MB2x5:VLS

TO: PP2 - Joyce Wood

FROM: N - K. E. Taggart K E Taggart

SUBJECT: DEIS 8306.22 - Operation of Limerick Generating Station, Units 1 and 2 (Docket Nos. 50-352/353), Schuylkill River, Montgomery County, Pennsylvania

The subject statement has been reviewed within the areas of the National Ocean Service's (NOS) responsibility and expertise, and in terms of the impact of the proposed action on NOS activities and projects.

NOAA-1 Geodetic control survey monuments may be located in the proposed project area. If there is any planned activity which will disturb or destroy these monuments, we require not less than 90 days' notification in advance of such activity in order to plan for their relocation. We recommend that funding for this project include the cost of any relocation required for NOS monuments. For further information about these monuments, please contact Mr. John Spencer, Chief, National Geodetic Information Branch (N/CG17), or Mr. Charles Novak, Chief, Network Maintenance Section (N/CG162), at 6001 Executive Boulevard, Rockville, Maryland 20852.

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

Food and Drug Administration
Rockville MD 20857

JUL 29 1983

Mr. A. Schwencer
Licensing Branch No. 2
Division of Licensing
US Nuclear Regulatory Commission
Washington, DC 20230

Dear Mr. Schwencer:

The National Center for Devices and Radiological Health (NCDRH) staff has reviewed the Draft Environmental Statement (DES) related to the operation of Limerick Generating Station, Units 1 and 2, NUREG-0974 dated June 1983.

In reviewing the DES, we note that (1) the application for the construction permit was filed on February 26, 1970, (2) the Final Environmental Statement - Construction Phase (FES-CP) was issued in November 1973, and (3) construction permits for Units 1 and 2 were issued on June 19, 1974. The Radiological Health staff of the NCDRH has evaluated the public health and safety impacts associated with the proposed operation of the plant and has the following comments to offer:

1. The design objectives contained in Appendix I of 10 CFR 50 and in the EPA Uranium Fuel Cycle Standards, 40 CFR 190, as well as the applicant's proposed radioactive waste management system, provide adequate assurance that radioactive materials in the effluent will be maintained as low as reasonably achievable (ALARA). It appears that calculated doses to individuals and to the population resulting from effluent releases are within current radiation protection standards.

2. The environmental pathways identified in Section 5.9.3 and Figure 5.4 cover all possible emission pathways that could impact on the population in the environs of the facility. The dose computational methodology and models (Appendix B and D) used in the estimation of radiation doses to individuals and to populations within 80 km. of the plant have provided the means to make reasonable estimates of the doses resulting from normal operations at the facility. Results of the calculations are shown in Appendix D, Tables D-6, D-7, D-8 and D-9. These results confirm that the calculated doses meet the design objectives.

FDA-1

3. It is noted that the environmental impacts of postulated accidents will be published in a supplement to this DES. We will forego any comments until we have had an opportunity to review the supplement.

C002
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4. The radiological monitoring program, as presented in Section 5.9.3.4 and summarized in Tables 5.8, appears to provide adequate sampling frequencies in critical exposure pathways. We understand that the operational monitoring program will be a continuance of the preoperational radiological monitoring program outlined in Table 5.8. The analysis for specific radionuclides are considered sufficiently inclusive to measure the extent of emission from the plant, as well as to verify that such emissions meet applicable radiation protection standards.

FDA-2 As stated above, the monitoring program is considered adequate for routine operations. However, it would be helpful if a paragraph could be added to Section 5.9.3.4 that indicated the capabilities of the monitoring instrumentation to measure releases from the facility in the unlikely event of an accident. We are concerned about some of the monitoring problems that were identified during the Three Mile Island, Unit 2 accident. In particular, the problem of monitoring radiohalogens (especially radioiodine) in the presence of radionoble gas. This could be accomplished by reference to FEMA-REP-2, a document on instrumentation prepared with considerable input from NRC.

5. Section 5.10 and Appendix C contain descriptions of the environmental impact of the Uranium Fuel Cycle (UFC). The environmental effects presented are a reasonable assessment of the population dose commitments and health effects associated with the release of radon-222 from the UFC.

Thank you for the opportunity to review and comment on this Draft Environmental Statement.

Sincerely yours,

John C. Villforth
Director
National Center for Devices
and Radiological Health

U.S. Department of Housing and Urban Development
Philadelphia Regional Office, Region III
Curtis Building
6th & Walnut Streets
Philadelphia, Pennsylvania 19106

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AUG 5 1983

Mr. A. Schwencer, Chief
Licensing Branch No. 2
Division of Licensing
Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Schwencer:

We have completed our review of the Draft Environmental Statement related to the operation of Limerick Generating Station, Units 1 and 2. It is our conclusion that matters of concern to this Department are adequately dealt with and we have no comments to offer.

Thank you for the opportunity to comment.

Sincerely,

Harry W. Staller

Kenneth J. Finlayson
Regional Administrator, 3S

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United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

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AUG 26 1983

U.S. Nuclear Regulatory Commission
Attention: Director, Division of Licensing
Washington, D.C. 20555

Dear Sir:

The Department of the Interior has reviewed the draft environmental impact statement for the Limerick Generating Station, Units 1 and 2 (OLS), Montgomery County, Pennsylvania and has the following comments.

Surface Water Hydrology

DOI-1 Section 4.3.1.1.3 notes that upstream reservoirs can maintain a flow of 3,000 cfs at Trenton during a moderate drought. This is incorrect. Records show that the existing reservoirs could not even maintain 2,500 cfs flow at Trenton during a drought one fourth as severe as the 1960's drought. In fact, historical flow records show that flows have dropped below 2,500 cfs at Trenton in every month except March, April and May even with 90 percent of the existing upstream storage in operation. With all the storage listed on page 4-21 in operation, flows at Trenton dropped below 2,500 cfs during four months in 1977, one month in 1980, and three months in 1981. In January 1981, the flow in the river was only 1,900 cfs at Trenton. The Delaware River Basin Commission (DRBC) now admits that by the year 2000, they may not be able to maintain a 2,300 cfs flow at Trenton because of increased consumptive losses in the basin. For example, the 1980 Delaware River Level B Study reported consumptive withdrawals of 1,495 cfs in 1980 with projections of 2,503 cfs by the year 2000. Furthermore, by virtue of a 1954 Supreme Court decree, New York City and New Jersey can remove up to 1,395 cfs from the basin. The Level B Study also reports that over 125 water purveyors are expected to have deficiencies in allocation, storage and yield by the year 2020. The DRBC recognizes that several more large reservoirs must be constructed in the basin to achieve the minimum flow objectives at Trenton.

We recommend that the paragraph be revised to reflect the severity of the low flow problems in the Delaware River and the inability of present practices to adequately deal with the problem.

DOI-2 It is unclear whether the 27 cfs pumping rate to be maintained throughout the low flow season is for water withdrawn from the Delaware River or from Bradshaw Reservoir. The applicant would be required to maintain a discharge of 10 cfs into the East Branch of Perkiomen Creek, not 10 cfs in Perkiomen Creek. The minimum flow of record in Perkiomen Creek is 4.7 cfs and the Q7-10 flow is 17.7 cfs. The final statement should clearly indicate what requirements will be placed on the applicant to maintain flows in the Perkiomen Creek Basin.

DOI-3 A 10 percent loss of water in transport from the Delaware River to the Limerick Generating Station has been estimated. This may be very conservative considering the evaporative losses in Bradshaw Reservoir and over 23 miles of Perkiomen Creek, leakage from transmission pipes and Bradshaw Reservoir, channel storage, and groundwater intrusion.

All of Montgomery County and parts of Bucks, Lehigh, Berks and Chester Counties were declared a "groundwater protected area" by the DRBC on October 8, 1980, because of over-withdrawal from groundwater. Approximately 220 miles of streams are directly impacted by induced groundwater intrusion and another 182 miles adversely affected by reduced flows. Studies by Chester-Betz Engineers and Moody Associates identified at least one mile of the East Branch of Perkiomen Creek downstream from the discharge point as a groundwater intrusion area. The studies also revealed that water discharged from Greenlane Reservoir on Perkiomen Creek is lost to groundwater before it reaches the Philadelphia Water Company's pump-out point near the mouth of Perkiomen Creek. Water will be conveyed in Perkiomen Creek during dry weather at the same time overpumping of groundwater will be most severe. We believe that losses in transit may be far greater than previously estimated. We recommend that transit loss estimates include potential losses from groundwater intrusion and evaporation as well as transmission pipe leakage.

Aquatic Resources

DOI-4 Collection of eggs and larval American shad, alewife, and blueback herring in 1982 confirms that the area in the vicinity of the Point Pleasant intakes is also used for spawning by alosids. As the alosid population in the river increases, we expect this area to be used more heavily for spawning in the future. The text should be revised to reflect the most recent information.

Water Use and Treatment

DOI-5 The data presented in this section does not clearly explain what the actual consumptive water loss will be at the power plant. Table 4.1 shows the maximum use of Delaware River water to be 57.4 cfs and a maximum evaporation loss of 56.6 cfs. Since the maximum water withdrawal from the Delaware River at Point Pleasant will be 71 cfs and 65 cfs on Perkiomen Creek as noted on page 4-10, it appears there will be a 13.6 cfs loss of water in transit to the plant. If so, the statement should be revised to more clearly discuss how much water will be lost.

Table 4.1 shows water will not be withdrawn from the Delaware River from November through May. Once water is withdrawn from the Delaware River, the applicant will be required to maintain a pumping rate of 27 cfs during the normal low flow season and 10 cfs flow in Perkiomen Creek for the remainder of the year. Flows have dropped below 530 cfs (which requires the applicant to use the Delaware River) in nearly every month of the year at the Pottstown gage on the Schuylkill River upstream of the Limerick Generating Station. Therefore, some pumping from the Delaware River may be required year-round to meet the DRBC flow requirements. We recommend this section clearly state the range of consumptive water loss and indicate the potential for year-round pumping from the Delaware River.

Water Quality

DOI-6 Although Delaware River water quality has been described as very good, there is evidence of pollution by at least two metals. The data used by the DRBC and subsequently by the Pennsylvania Department of Environmental Resources were from monthly grab samples and some 24 hour composite samples. Monthly grab samples are inadequate to accurately represent the quality of flowing water. Only continuous monitoring could achieve the accuracy implied by the text. Whole fish flesh analysis of fishes taken from the Delaware River at the I-95 bridge 18 miles south of Point Pleasant and at Upper Black Eddy 15 miles north of Point Pleasant indicate high levels of cadmium and lead. The level in these Delaware River fish fall in the upper 15 percent of all samples collected nationwide as part of the National Pesticide Monitoring Program. As noted on page 4-29, state standards for cadmium have been violated in the Delaware River.

DOI-7 Sampling data by the Merrill Creek Owners Group 25 miles upstream of the proposed project shows peaks of 0.9 mg/l total phosphorous and 0.75 mg/l orthophosphate after storms. (It is noted on the bottom of page 4-26 that phosphorous limits are violated at the Point Pleasant intake site.) Even with a three day turnover rate in Bradshaw Reservoir, such high levels of phosphorous could cause agal blooms in the reservoir. With lower pumping rates, detention time would increase and the potential for agal blooms would be even higher. Heavy agal blooms could degrade water quality and cause anoxic conditions. This poorer quality water would than be withdrawn from the reservoir and discharged to Perkiomen Creek.

DOI-8 Water intakes on the Delaware River are only 800 feet downstream from Tohickon Creek. Route 32 crosses Tohickon Creek approximately 200 feet upstream of its confluence with the Delaware River. A chemical spill accident at the Route 32 bridge would quickly travel downstream and be drawn into the Point Pleasant intake, and eventually contaminate Bradshaw Reservoir. Depending on the nature of the chemicals involved, pollutants could eventually find their way to Perkiomen Creek.

Environmental Consequences

DOI-9 To calculate the highest possible percentage of the flows that would be withdrawn by Limerick, a flow of at least 3,000 cfs is assumed to be maintained at Trenton. We are not sure why the 3,000 cfs value is used since even a cursory examination of USGS gaging records show that flows of less than 3,000 cfs are not an uncommon occurrence. In fact, the low flow at the Trenton gage was 1,180 cfs (October 1962). As recently as January 1981, the flows at Trenton dropped to 1,900 cfs. At a flow of 1,180 cfs, the Point Pleasant project would withdraw 12.3 percent of the river water. Since it is the extreme fluctuations that most significantly impact fish and wildlife resources, it is misleading not to evaluate the extremes as part of the impact assessment. The text should be changed accordingly.

DOI-10 The statement that Limerick will not be permitted to withdraw water when flows at Trenton fall below 3,000 cfs is unrealistic. Flows at Trenton have fallen below 3,000 cfs numerous instances since U.S. Geological Survey (USGS) began keeping records. Yet we are unaware of a single instance when DRBC has required anyone to stop withdrawing water because of low flows at Trenton. We recommend this sentence be deleted and this section be revised to reflect customary practice.

DOI-11 Cumulative impacts from water withdrawals in the basin have been ignored. The final statement should discuss the combined effects of: over-allocating water in the basin; diverting a maximum of 1,395 cfs to New York City/New Jersey; over-pumping groundwater; excessive consumptive withdrawals; and the lack of adequate make-up water storage in the basin on salinity intrusion in upper Delaware Bay. Model runs of the Thatcher/Harleman salinity model for Delaware Bay have never taken the reduced flows from over-pumping groundwater into account in their consumptive use estimates. The large Raritan-Magothy-Potomac Aquifer passes under the Delaware River south of Camden, New Jersey and is currently being pumped at three times its recharge rate near Camden. According to the USGS, lower water tables have actually caused water from the Delaware River to flow into the groundwater.

DOI-12 Also, the DRBC salinity model assumes a minimum flow of 2,700 cfs yet the average monthly flow for January 1981, was 2,539 cfs (minimum daily of 1,900 cfs) during a drought only one-fourth as severe as the 1960's drought. Adequate storage does not now exist in the basin to maintain target flows at Trenton.

The progressive decrease in freshwater input and rising sea level has resulted in higher salinity levels in Delaware Bay. A study by Dr. Harold H. Haskin (1972) showed significant increases in salinity at five locations in Delaware Bay over a 41-year period. Model runs by the Thatcher/Harleman Salinity Model predicted greater than 15 ppt isohaline levels over the seed oyster beds in the estuary year-round during dry years (the model run assumed only a 1,000 cfs consumptive use and 2,700 cfs river flow at Trenton). Seed oyster beds are an important part of a multi-million dollar industry in Delaware Bay. Salinity levels above 15 ppt isohaline allow the seed oysters to be attacked and destroyed by the oyster drill and the protozoan MSX. The DRBC study on the effects of rising sea level on salinity identified the need for 3-10 cfs/year more freshwater input to maintain existing salinity regimes in Delaware Bay.

DOI-13 A similar argument for the cumulative effects of water withdrawals can be seen with dissolved oxygen in the estuary. The DRBC dissolved oxygen model shows a direct relationship between river flows and dissolved oxygen in Zone II of the Delaware estuary. Water withdrawn at Point Pleasant will bypass all but three miles of Zone II. Even slight changes in flow of 200-300 cfs can cause more than a 1 mg/l change in dissolved oxygen in Zone II. Diadromous fishes must pass through Zone II of the estuary to reach spawning and nursery areas in the Delaware River. Therefore, it is crucial to the continued existence of these runs to have adequate levels of dissolved oxygen for passage in the spring and fall. Low dissolved oxygen levels are suspected of causing poor repeat spawning by adult American shad and large die-offs of juvenile American shad in the Delaware River estuary. The final statement should assess this issue.

DOI-14 We disagree that there will not be water quality problems in the East Branch of Perkiomen Creek. Weekly samples at the proposed Merrill Creek Reservoir intake 25 miles upstream on the Delaware River had a range of orthophosphate between 0.01 to 0.75 mg/l. With a short detention time in Bradshaw Reservoir, up to four times the level of organic phosphates could be discharged to the East Branch stimulating nuisance agal blooms and plant growth downstream.

Aquatic Resource Impact Summary

DOI-15 Because the Delaware River also has withdrawal restrictions for the Point Pleasant project, make-up water storage capacity on the Delaware River is necessary. When the proposed project was originally planned, DRBC assumed that existing storage capacity was available. However, recent droughts have demonstrated that existing storage cannot even meet the current water demands. Therefore, the applicant has entered into an agreement to help build the Merrill Creek Project. The Merrill Creek Project will inundate 712 acres of high quality wildlife habitat including 1.7 miles of a native brook trout stream. The brook trout is a State-designated threatened species. Habitat for the State-designated threatened longtail salamander and the State-designated endangered cooper's hawk will also be lost. Despite the fact that Merrill Creek is necessary for operating the Limerick Generating Station under all flow conditions, there is very little discussion in the statement about the Merrill Creek project and nothing about the habitat losses and disturbance from operation of this project. We recommend the draft statement be revised to discuss impacts from the Merrill Creek Project and that less environmentally damaging make-up water storage options in the Schuylkill River Basin be seriously considered.

Unavoidable Adverse Impacts

DOI-16 The draft statement (OLS) does not adequately address impacts to fish and wildlife resources nor does it reflect the most recent information pertaining to fish and wildlife resources impacted by the project. The impact assessment in this statement for the Point Pleasant Diversion relies heavily on data previously prepared by the Delaware River Basin Commission (DRBC). We believe the assumptions used by DRBC in the original models to generate this data are no longer valid, based on the most recent information available.

We do not agree that project operations will have no adverse impacts to fish and wildlife resources. The potential exists for cumulative adverse impacts to water quality in the Delaware estuary and to increased salinity intrusion in upper Delaware Bay. Water quality may be degraded in Perkiomen Creek during diversions from the Delaware River. The potential also exists for entrainment and impingement of eggs and larval fishes by the Point Pleasant intakes.

DOI-17 The potential for impacts on ground-water resources as a result of a Class 9 accident involving penetration of the basemat by reactor core debris is especially worthy of analysis at the Limerick site. This is true because the Brunswick aquifer is characterized by secondary permeability derived largely from vertical joints as noted on page 4-22. The existence of such permeability may permit relatively rapid movement of contaminants in ground water in the event of a melt through of the basemat and resulting escape of contaminants from the containment.

DOI-18 Fish and Wildlife Coordination Act

These comments do not preclude separate evaluation and comments by the Fish and Wildlife Service (FWS) pursuant to the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), since the proposal to construct the dam and water intake structures will require Section 404 permits from the Corps of Engineers.

POINT PLEASANT

On October 18, 1982, the FWS recommended denial of the Department of the Army permit (Public Notice No. NAPOP-8-0534-3, dated April 6, 1981) to the Neshaminy Water Resource Authority. The reasons for the recommendation of denial were:

1. Cumulative effect of water withdrawals on salinity intrusion in Delaware Bay.

No studies have assessed the combined effects of over-allocation of water in the basin, maximum New York City/New Jersey diversion of 1,340 cfs, over-pumping of ground water, total consumptive withdrawals within the basin and lack of adequate make-up water storage in the basin on saltwater intrusion in upper Delaware Bay. Studies have documented increased salinity levels in Delaware Bay and the adverse impacts of reduced freshwater inflows on seed oyster production. The model runs of the Thatcher/Harleman salinity model for Delaware Bay have never taken into account their consumptive use figures the reductions in surface flow from over-pumping ground water (induced groundwater intrusion). The model runs have also assumed adequate storage upstream to maintain a minimum flow at Trenton, New Jersey of 2,700 cfs. Flows at Trenton, New Jersey in January 1981 dropped to 1,900 cfs and the average for the month was only 2,539 cfs.

2. Cumulative effect of consumptive water withdrawal on dissolved oxygen.

All the water withdrawn at Point Pleasant will bypass 41 miles of the Delaware River including all but 3 miles of Zone II of the Delaware River estuary. Water returning to the river via Wissahickon Creek will bypass 70 miles of the Delaware River and all of Zones II and III of the estuary. Since 1965, flows low enough to cause severe dissolved oxygen sags in the estuary have occurred in every month. Low dissolved oxygen has been blamed for poor repeat spawning by adult American shad and large die-offs of juvenile American shad in the Delaware River estuary.

3. Impacts to the North Branch Neshaminy Creek and East Branch Perkiomen Creek.

Increased discharges to both creeks will scour stream banks and stream bottom, increasing turbidity and sedimentation downstream. Increased phosphate loading of Lake

Galena will accelerate eutrophication and cause water quality problems. Whole fish flesh analysis of fish taken from the Delaware River at the I-95 bridge (18 miles south of Point Pleasant) and Upper Black Eddy (15 miles north of Point Pleasant) indicate high levels of cadmium and lead. The levels in these Delaware River fish fall in the upper 15 percent of all samples collected nationwide as part of the National Pesticide Monitoring Program. Delaware River water will degrade water quality in both streams by introducing higher levels of cadmium and lead. Several groundwater intrusion areas have been identified in Perkiomen Creek due to over-pumping of ground water. Surface water from the Delaware River will be lost to ground water when discharged into Perkiomen Creek and could potentially contaminate groundwater supplies.

4. Impacts to fish and wildlife resources in the Delaware River at the intake site.

The pipeline to the pumphouse will disturb one acre of riverine, forested wetland and permanently destroy 0.3 acre. The intake is at the edge of a large back eddy formed below Tohickon Creek. The eddy is a spawning and nursery area for American shad, river herring, channel catfish, smallmouth bass, redbreast sunfish, bluegills and black crappie. At low flows the intake will be in the back eddy and will entrain or impinge eggs and larval fish.

5. Impacts from the Merrill Creek Reservoir.

The Point Pleasant Diversion was part of the justification for building the Merrill Creek Reservoir. The Merrill Creek project would inundate 1.7 miles of brook trout stream, flood 712 acres of valuable wildlife habitat and destroy habitat for three State-designated endangered species. There are reservoir sites on the Schuylkill River that would be less environmentally damaging and eliminate the need for the Point Pleasant Diversion.

MERRILL CREEK

In reviewing applications for permits, the FWS recommended denial for the following reasons:

1. Loss of 712 acres of valuable wildlife habitat, including habitat for State-designated threatened species (the longtail salamander and brook trout), and State-designated endangered Cooper's hawk.

2. Loss of 1.7 miles of native brook trout stream.

3. No mitigation plan to compensate for loss of fish and wildlife habitat.

4. The least environmentally damaging alternative was not selected.

5. Inadequate minimum releases from the reservoir into Merrill Creek to protect brook trout habitat downstream.

6. Impacts from the proposed intake structure on the Delaware River.

7. Entrainment and impingement problems at the intake on the Delaware River, especially American shad.

8. Withdrawal of water during low river flows will result in cumulative adverse impacts downstream.

We hope these comments will be helpful to you in the preparation of a final statement.

Sincerely,

Terence N. Martin

for Bruce Blanchard, Director
Environmental Project Review

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
6TH AND WALNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

AUG 15 1983

Dr. Rajender Auluck, P.E., Project Manager
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Dr. Auluck:

EPA has completed its review of the draft EIS for operation of the Limerick Generating Station, as required under Section 309 of the Clean Air Act. In general, the document is acceptable with certain exceptions enumerated in the attached technical comments. As a result of the review, the draft EIS is rated ER-2, which means that the environmental reservations are related to insufficient information. The attached sheet describes the rating system used by EPA and is enclosed for your information.

In late 1980 and early 1981, the EPA EIS review staff met with the DRBC and PaDER several times to clarify environmental issues related to the Neshaminy Creek Watershed Plan and Water Supply Plan. The issues discussed had been raised in a letter to DRBC, dated September 26, 1980, and supplemented in subsequent meetings. The issues included analysis of flows, population and water use projections, water conservation controls, and the relationship of the Philadelphia Electric Company needs (described in Docket No. 79-52-CP) as it relates to components of the NWRA watershed and water supply plans. These meetings resolved our technical concerns regarding the NWRA portion of the diversion proposal and resulted in our conclusion that the potential benefits to be derived from the diversion, as claimed in the various Dockets, far outweighed any potential adverse impacts. This is the position EPA took in a letter dated February 17, 1981 to Governor Tribbet of Delaware, who was then the U.S. Commissioner of DRBC.

The majority of the following comments are concerned with radiation and cooling water with regard to its sources and receiving streams. In some cases the radiation information is incompletely addressed while in other places it is presented in a way that is confusing to the reader. The major deficiencies regarding radiation are: a) treatment of EPA standards, b) a lack of information on postulated accidents, and c) a lack of information on decommissioning.

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With regard to the cooling water discussions, the document is inconsistent in its presentation of the water budget and the needs. Major deficiencies in the water area of concern are: a) cooling water budget inconsistencies, b) the range of cooling water needs for differing operating configurations, c) aquatic impacts of flow extremes in diversion and receiving streams that may occur over short time spans, and d) dilution for water quality improvement in the lower portion of the East Branch Perkiomen Creek. These are the two major areas addressed in the comments and are followed by some air pollution concerns and other minor points.

We appreciate the opportunity to review the document and your staff's cooperation. If any points require further discussion or clarification, please contact Mr. Robert Davis of the EIS Review Team. He can be reached on 215-597-4388.

Thank you.

Sincerely,

Henry P. Brubaker
Chief, Analysis and Services Section

Enclosure(s)

Technical Comments

Radiation Concerns:

EPA-1

A most important concern is the treatment of the EPA standards for the uranium fuel cycle given in 40 CFR 190. These standards are fleetingly addressed on pages 5-38 and 5-48, 49. The standards are incompletely described and are addressed only by the vague statement that "under normal operations the Limerick facility is capable of operating within these standards." This statement does not state whether or not the plant actually will operate within the standards, and more importantly only a part of the standard is referenced by ~~the~~ DEIS. Attached is a copy of 40 CFR 190 for your information. In a careful study of the DEIS, we have found that information is supplied on pages 5-64 and D9-D11 which may be compared to the EPA standard, but the information is not presented in an understandable format and there is some question as to whether the standard for release of krypton-85 will be met. The EPA standards should be directly and completely addressed in the EIS in tabular form so that projected releases may be directly compared to the standard. The standard is applicable only to normal operations.

EPA-2

In addition, there is a lack of information on postulated accidents and on the radwaste system. On pages 5-61 it is stated that NRC's review of the utility's probabilistic risk assessment has not yet been completed and "will be factored into the NRC staff's analysis . . . to fulfill the requirement of this section of the DES." The radwaste issues are to be addressed in Chapter 11 of the SER. Both of these issues are an integral part of the environmental impacts of the plant and should be considered as a part of the NEPA process. No final EIS should be issued before these issues are reviewed by EPA and supplemental comments provided to NRC.

EPA-3

As a final note on the radiological portion of this review, the impacts of decommissioning are only briefly mentioned in passing. At least a general order of magnitude of these impacts should be discussed, though specific numerical estimates of the impacts are probably not yet available.

EPA-4

Hydrology and Cooling Water:

Information presented in the document regarding hydrology is in agreement with information available to the EPA technical staff. However, some serious questions have been raised over the cooling water sources and uses.

Questions are raised concerning withdrawal flows presented in Table 4.1 and Section 4.2.4. Page 4-10 indicates a maximum withdrawal rate of 95 MGD from the Delaware River. Of this, a maximum of 46 MGD will be diverted to Limerick. However, Table 4.1 shows a maximum flow of 37 MGD from the Delaware/ Perkiomen. This apparent inconsistency should be explained.

Page 4-12 indicates a maximum withdrawal rate of 41.9 MGD from Perkiomen is expected. However, this does not match with the maximum flow of 46 MGD diverted to Limerick, as stated on page 4-10, nor does it match the flows in Table 4.1 for the Perkiomen. Again the apparent inconsistency should be explained.

These inconsistencies may be serious, with implications reaching from operation of the Point Pleasant diversions all the way to the range of possible effects upon the final receiving stream. These could impact the Bradshaw reservoir, the East Branch of the Perkiomen Creek, the Perkiomen Creek, the Schuylkill at the confluence with the Perkiomen, and downstream.

EPA-5 Section 4.2.4 should detail the current conditions of those streams to receive diversion water more thoroughly than is done. For example, virtually nothing is included regarding the conditions of the riparian habitat or the flood plain, and in chapter 5 no mention is made of the effects under extreme conditions, e.g., high flows of short duration. We agree that diverted water will result in negligible effects most of the time and furthermore will probably have beneficial effects ecologically. However, extremes should be thoroughly explained. In addition, very little is mentioned regarding the effects of the environmental ramifications of flows 4 to 25 times normal. You have included information that flows are below the highest flows and that they are well within the erosion limits, but disclosure should go beyond merely the water quality conditions. The answers are probably available and deserve inclusion, if only by reference.

EPA-6 In addition, no mention is made of the effects the Pennsylvania Public Utility Commission decision regarding unit two. If only one unit is ever operated, what are the implications for the cooling water budget both from the Point Pleasant diversion and the Schuylkill? Since this possibility has been disregarded, we have no way of estimating any aquatic impacts that may result from differing operational configurations. If only one unit is ever brought on-line, alternative sources of cooling water may be available. In this case, diversion of water into the East Branch of the Perkiomen may be unnecessary.

EPA-7 Part of the operational plans mentioned in the document are concerned with the use of releases from the yet to be constructed Merrill Creek facility. Admittedly, all the ramifications of this are unknown, but it seems apparent that releases from that facility will seldom be needed. However, if that facility is necessary for the successful operation of the LGS then what contingency has been planned in the event that the Merrill Creek facility is precluded? This as well as other impoundments appears to be crucial to future water quality in the Delaware.

EPA-8 Recent information indicates that DRBC is continuing to update the modeling of the Delaware, especially with regard to the salinity criteria. As we understand it, the latest salinity objective for the year 2000 is unachievable under current operational modes of existing and planned impoundments and diversions. Apparently a need exists to adjust the opertional configuration of these projects to achieve the salinity objective. Aside from the fact that DRBC has a plethora of alternatives to consider and quite a few years to develop and examine them, still the demands by Limerick are certainly a part of the Point Pleasant diversion and certain to be a concern in the deliberations over the salinity issue. Therefore, the salinity issue and operation of the Limerick plant are related and the basin's overall water budget into the future may effect the operation of the Limerick plant. Sections 5.3 or 5.3.2.3 should include discussions regarding salinity and the EIS should include information on the impacts expected from the various operational configurations, both for the LGS as well as for the dams and diversions.

EPA-9 An apparent inconsistency exists in statements under Section 4.3.2.1 (p. 4-3) and 5.3.2.2 (p. 5-3). In the first case it is stated that no changes in the overall scheme for water use has occured while on page 5-3 it is stated that several changes in the design have taken place. The reviewers assume that these changes have been made to accommodate water quality implications, however, no information is presented to tell why such changes were necessary and why such drastic efforts were needed for what appear to be incremental improvements. On the other hand, perhaps these design efforts have been made for larger improvements than are expressed. If this is so, then the document should discuss design changes discarded and why.

EPA-10 Another inconsistency exists regarding benefits to accrue from the Point Pleasant diversion. In Docket No. D-65-76CP (8), DRBC has eliminated dilution and augmentation as Point Pleasant diversion benefits for the Neshaminy, but the draft EIS claims such benefits for the East Branch Perkiomen. This appears to be inconsistent because it is a claim of convenience in spite of the fact that apparently dilution is the easiest means for improving the lower portion of the East Branch.

EPA-11 In Section 5.3.2.3, operation of the diversion and its environmental effects are discussed. It is understood that once the diversion of water to Limerick is begun the flows will be maintained so that extremes in fluctuation of water levels in the streams used for diversion will be avoided. However, no mention is made of how the diversion will be operated so that flash floods resulting from short duration/high intensity storms will not be exacerbated. There may be no cause for concern here, but some attention should be paid to the possibility, especially in light of the lack of riparian habitat along the streams of the area. In other words, much of the flood plain in the area has been changed so that it is now dedicated to agriculture or to activities other than flood way.

Air Concerns:

EPA-12 Under air impacts on page 5-24, the emissions are estimated to be "less than EPA de minimus levels" for certain pollutants. These de minimus levels are probably those used for PSD purposes. No information is given on the actual off-site ambient concentrations that will result. While the low emissions will most likely result in very small impacts, this does not justify the complete lack of any numerical data to backup this assertion. At a minimum, annual and maximum 24-hour emissions should be given. A simple model could then be run to estimate off-site concentrations. If these are truly as small, this will reinforce the conclusion that the impacts are too small to be significant.

EPA-13 Finally, on page 5-15, first paragraph, the last sentence states that "Actions to mitigate these potential impacts (from cooling tower chlorination) should be considered . . .". This statment constitutes a recommendation to the utility and is out of place in an EIS. It would be more appropriate to discuss what will be done, what are the alternatives and what mitigative actions will be implemented.

Other Concerns:

The following are some minor points and are offered for your consideration and information.

EPA-14 1) On page 4-37 mention is made of the possibility of the presence of eels in the Delaware. This is very likely, especially in light of the fact that a small eel fishery exists in the Port Jervis area, far upstream of the diversion intake.

EPA-15 2) The document contains some very assured statements regarding the ultimate improvement in quality of the streams receiving diversion water. However, monitoring in conjunction with operation of the diversion should be carried out for all parameters contained in the draft EIS as well as for the fish community. A good start has been made, as described in Section 4, of the trophic levels in all the streams. This should be expanded and continued as the diversion is completed and placed into operation.

EPA-16 3) Section 5.3.2.3 describes the nonthermal water quality anticipated for the Bradshaw facility and the Delaware. A statement is made that the reservoir will act as both a sediment controlling facility as well as a phosphorous sink. However, no mention is made regarding the nonsettleable fraction which will pass through the reservoir and may negate any phosphorous control claimed as a benefit of the reservoir. Perhaps some reassessments are in order if the modelling for receiving stream water quality has not included this source of phosphorous. In addition, we failed to see any statements covering retention time in the Bradshaw facility. Information from other sources indicates that sediment control is not achieved with flows greater than 10% of total capacity flow through per day. However, this is an optimum figure that is adjusted on a case-by-case basis. In any event, the claims made by the NRC for sediment control using the Bradshaw facility should be substantiated statistically in the final EIS.

EPA-17 4) The next-to-last paragraph on page 5-25 states that "... induced shock will adversely affect biota along the Limerick Transmission corridor." Perhaps this is a typographical error because the remainder of the paragraph describes just the opposite. However, if this is not an error, then this section needs to be rewritten.

SUBCHAPTER F—RADIATION PROTECTION PROGRAMS

PART 190—ENVIRONMENTAL RADIATION PROTECTION STANDARDS FOR NUCLEAR POWER OPERATIONS

AUTHORITY: Atomic Energy Act of 1954, as amended; Reorganization Plan No. 3, of 1970.

SOURCE: 42 FR 2860, Jan. 13, 1977, unless otherwise noted.

Subpart A—General Provisions

§ 190.01 Applicability.

The provisions of this part apply to radiation doses received by members of the public in the general environment and to radioactive materials introduced into the general environment as the result of operations which are part of a nuclear fuel cycle.

§ 190.02 . Definitions.

(a) "Nuclear fuel cycle" means the operations defined to be associated with the production of electrical power for public use by any fuel cycle through utilization of nuclear energy.

(b) "Uranium fuel cycle" means the operations of milling of uranium ore, chemical conversion of uranium, isotopic enrichment of uranium, fabrication of uranium fuel, generation of electricity by a light-water-cooled nuclear power plant using uranium fuel, and reprocessing of spent uranium fuel, to the extent that these directly support the production of electrical power for public use utilizing nuclear energy, but excludes mining operations, operations at waste disposal sites, transportation of any radioactive material in support of these operations, and the reuse of recovered non-uranium special nuclear and by-product materials from the cycle.

(c) "General environment" means the total terrestrial, atmospheric and aquatic environments outside sites upon which any operation which is part of a nuclear fuel cycle is conducted.

(d) "Site" means the area contained within the boundary of a location under the control of persons possessing or using radioactive material on which is conducted one or more operations covered by this part.

(e) "Radiation" means any or all of the following: Alpha, beta, gamma, or X-rays; neutrons; and high-energy electrons, protons, or other atomic particles; but not sound or radio waves, nor visible, infrared, or ultraviolet light.

(f) "Radioactive material" means any material which spontaneously emits radiation.

(g) "Curie" (Ci) means that quantity of radioactive material producing 37 billion nuclear transformations per second. (One millicurie (mCi)=0.001 Ci.)

(h) "Dose equivalent" means the product of absorbed dose and appropriate factors to account for differences in biological effectiveness due to the quality of radiation and its spatial distribution in the body. The unit of dose equivalent is the "rem." (One millirem (mrem)= 0.001 rem.)

(i) "Organ" means any human organ exclusive of the dermis, the epidermis, or the cornea.

(j) "Gigawatt-year" refers to the quantity of electrical energy produced at the busbar of a generating station. A gigawatt is equal to one billion watts. A gigawatt-year is equivalent to the amount of energy output represented by an average electric power level of one gigawatt sustained for one year.

(k) "Member of the public" means any individual that can receive a radiation dose in the general environment, whether he may or may not also be exposed to radiation in an occupation associated with a nuclear fuel cycle. However, an individual is not considered a member of the public during any period in which he is engaged in carrying out any operation which is part of a nuclear fuel cycle.

(l) "Regulatory agency" means the government agency responsible for issuing regulations governing the use of sources of radiation or radioactive materials or emissions therefrom and carrying out inspection and enforcement activities to assure compliance with such regulations.

Subpart B—Environmental Standards for the Uranium Fuel Cycle

§ 190.10 Standards for normal operations.

Operations covered by this subpart shall be conducted in such a manner as to provide reasonable assurance that:

(a) The annual dose equivalent does not exceed 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public as the result of exposures to planned discharges of radioactive materials, radon and its daughters excepted, to the general environment from uranium fuel cycle operations and to radiation from these operations.

(b) The total quantity of radioactive materials entering the general environment from the entire uranium fuel cycle, per gigawatt-year of electrical energy produced by the fuel cycle, contains less than 50,000 curies of krypton-85, 5 millicuries of iodine-129, and 0.5 millicuries combined of plutonium-239 and other alpha-emitting transuranic radionuclides with half-lives greater than one year.

§ 190.11 Variances for unusual operations.

The standards specified in § 190.10 may be exceeded if:

(a) The regulatory agency has granted a variance based upon its determination that a temporary and unusual operating condition exists and continued operation is in the public interest, and

(b) Information is promptly made a matter of public record delineating the nature of unusual operating conditions, the degree to which this operation is expected to result in levels in excess of the standards, the basis of the variance, and the schedule for achieving conformance with the standards.

§ 190.12 Effective date.

(a) The standards in § 190.10(a) shall be effective December 1, 1979, except that for doses arising from operations associated with the milling of uranium ore the effective date shall be December 1, 1980.

(b) The standards in § 190.10(b) shall be effective December 1, 1979, except that the standards for krypton-85 and iodine-129 shall be effective January 1, 1983, for any such radioactive materials generated by the fission process after these dates.

PART 192—ENVIRONMENTAL PROTECTION STANDARDS FOR URANIUM MILL TAILINGS

AUTHORITY: Sec. 275, Atomic Energy Act of 1954, (42 U.S.C. 2022), as amended by the Uranium Mill Tailings Radiation Control Act of 1978, Pub. L. 95-604.

SOURCE: 45 FR 27367, Apr. 22, 1980, unless otherwise notd.

Environmental Impact of the Action

LO--Lack of Objections

EPA has no objections to the proposed action as described in the draft impact statement or suggests only minor changes in the proposed action.

ER--Environmental Reservations

EPA has reservations concerning the environmental effects of certain aspects of the proposed action. EPA believes that further study of suggested alternatives or modifications is required and has asked the originating Federal agency to reassess these aspects.

EU--Environmentally Unsatisfactory

EPA believes that the proposed action is unsatisfactory because of its potentially harmful effect on the environment. Furthermore, the Agency believes that the potential safeguards which might be utilized may not adequately protect the environment from hazards arising from this action. The Agency recommends that alternatives to the action be analyzed further (including the possibility of no action at all).

Adequacy of the Impact Statement

Category 1--Adequate

The draft impact statement adequately sets forth the environmental impact of the proposed project or action as well as alternatives reasonably available to the project or action.

Category 2--Insufficient information

EPA believes that the draft impact statement does not contain sufficient information to assess fully the environmental impact of the proposed project or action. However, from the information submitted, the Agency is able to make a preliminary determination of the impact on the environment. EPA has requested that the originator provide the information that was not included in the draft statement.

Category 3--Inadequate

EPA believes that the draft impact statement does not adequately assess the environmental impact of the proposed project or action, or that the statement inadequately analyzes reasonably available alternatives. The Agency has requested more information and analysis concerning the potential environmental hazards and has asked that substantial revision be made to the draft statement.

If a draft impact statement is assigned a Category 3, ordinarily no rating will be made of the project or action, since a basis does not generally exist on which to make such a determination.

Figure 3-1. Notification of EPA's Classification of Comments
Page 2 of 2

MARYLAND
DEPARTMENT OF STATE PLANNING
301 W. PRESTON STREET
BALTIMORE, MARYLAND 21201-2365

HARRY HUGHES
GOVERNOR

CONSTANCE LIEDER
SECRETARY

MEMORANDUM

50-352/353

TO: Addressees

FROM: Guy W. Hager
Director, MD State Clearinghouse

DATE: December 20,1983

RE: State Clearinghouse Project Number 83-6-729
DEIS Operation of Limerick Generating Station, Units 1 and 2

Md.

The enclosed draft environmental impact statement on the previously reviewed referenced project is forwardered for your information and use. If you desire to comment further on the project, please contact the Nuclear Regulatory Commission within three weeks from the date of this memorandum and send an information copy of such response to this State Clearinghouse. If no response is received within this time period, it will be assumed that your agency has no further interest in commenting on the project, and that the requirements of the established procedures have been met.

Thank you for your attention to this matter.

GWH/ps

Enclosure

Addressees

Clyde Pyers - Transportation
Herbert Sachs - Natural Resources.(2 copies)
Lowell Frederick - Economic & Community Development
Max Eisenberg - Environmental Programs (2 copies)
Frank Hall - Safety & Corrections
Comprehensive - State Planning

Information Copy

A. Schwencer

TELEPHONE: 301-383-7875
OFFICE OF STATE CLEARINGHOUSE

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

JAN 09 1984

IN REPLY REFER TO
Environmental Resources Branch

50-352/353

Mr. A. Schwencer, Chief
Licensing Branch Number 2
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Schwencer:

DA/CE

The Philadelphia District, Corps of Engineers has reviewed the Supplement No. 1 to the Draft Environmental Impact Statement for the Limerick Generating Station, Units 1 and 2. We have no substantive comments to make regarding the focus of the Supplement No. 1, i.e., environmental impacts of the postulated plant accidents, and appreciate the opportunity to review this Supplement.

Sincerely,

Nicholas J. Barbieri, P.E.
Chief, Planning/Engineering Division

United States Department of Agriculture

Economic Research Service

Washington, D.C. 20250

January 27, 1984

Mr. A. Schwencer
Chief, Licensing Branch No. 2
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Schwencer:

DA/ERS Thank you for forwarding the Draft Environmental Statement concerning the issuance of operating licenses to the Philadelphia Electric Company for startup and operation of the Limerick Generating Station, Units 1 and 2 located south of Pottstown, Pennsylvania.

We have reviewed Docket Nos. 50-352 and 50-353 and have no comments.

Sincerely,

Velmar W. Davis

VELMAR W. DAVIS
Acting Director
Natural Resource Economics Division

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
6TH AND WALNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

February 3, 1984

Mr. Robert E. Martin
Project Manager
Office of Nuclear Reactor Regulation
U.S. NRC
Washington, D.C. 20555

Dear Mr. Martin:

EPA has completed its review of Supplement No. 1 to the Draft EIS for the Limerick Generating Station. The document represents what appears to be final results of a great deal of mathematical analyses. However, in many places it is difficult to know what is based upon analysis of historical events as they may relate to Limerick, and what is based upon probability theory related and derived from design parameters specific to Limerick.

The concensus here is that NRC looked at the risks associated with the plant itself, but not with the range of events that can be expected to occur off-site. An example is the transportation of fuel both to and from the facility. Even though this subject has been dealt with generically in another publication, events for this site and its surroundings should be thoroughly analyzed. Perhaps this could be properly dealt with through a comparison with non-nuclear facilities for shear numbers of accidents, and then working out comparative analysis for the gravity of events using parameters related to radioactive materials. In addition, the AMA carried out a comparative study in an attempt to qualify the risks from air pollution from alternate means of power generation. NRC may find this useful. EPA-1

The technical comments are categorized below for your consideration in preparing the final EIS.. It is hoped you will consider them seriously inasmuch as the analysis reflected in the document seems to be of sufficient depth to be acceptable, but at the same time summarizes possible events all too briefly. Because of this, the document is rated ER-2, as was the Draft EIS of which this risk assessment is a part.

If you have any questions or if we can be of further assistance, please contact Mr. Robert Davis of my staff.

Sincerely,

Henry P. Brubaker

Henry P. Brubaker, Chief
Analysis & Services Section

Technical Comments

1. Statistics and probability:

In spite of the uses made of information from historical events, it appears that much of the assessment for PRA is design based. As we understand it, this means that plant design incorporates certain parameters respresenting upset events so that their severity is minimized. Mathematical models can then be used to analyze in advance for SCRAM or worse, and develop a probability that has resulted in the reassuring scenario presented in this Supplement. It is assumed that designers have availed themselves of the broadest statistical bases possible, but the reader is often confused by the hybridization of probability and operational experience. It is implied throughout the document that GE has adjusted its design in accord with operational experience, but it is apparent that the statistical evidence for some of these changes is not in hand. The Zircaloy issue mentioned below is an example of where information has been culled out when it probably should not have been. EPA-2

In other words, terminology may be the culprit, or at least choice of words, because TMI was no accident: it was a design failure regardless of operator error, and looking at it even further it was a designed accident because if the plant had been designed differently the event presumably would never have occurred.

Appendix H relates to accident sequences and release categories that all seem to describe the ultimate cumulative disasters and their probabilities. It appears that uncertainty in the available data allows only a rough estimate of conseuences of events during reactor operation. It this an attempt to say at the same time that worst case analysis and minor events are all lumped together and that the minor events really fall into the same unlikely category, but since their consequences are so insignificant that they need not be analyzed? That is, no great consequence exists if a part of the operation represents a smaller risk than a large event, which is analyzed. However, no mention is made of the possibility that a small event may make an associated small event more likely by defeating a safety system. EPA-3 An example is the limits of temperature measurements. Design should include parameter monitors that operate independent of design operational limits, i.e., monitors that measure the entire spectrum of each integral part to be monitored. For example, the monitors and gauges related to core temperatures should be able to read possible range of core temperature and not be designed to the limits of plant operation. If this isn't done minor upsets can lead quickly to major ones regardless of the probability of any one occurring individually. Table H-1 attempts to tabulate all of the initiating events, but does not exhaust the possibilities. Is this table representative of the design or experience? EPA-4

In sum, we agree with the wording on 5-8, "The evidence of accident frequency ...is a useful indicator of ...probabilities and impacts.", but hasten to add that several different and evolving design configurations are being used, all of which are closely linked to research and development. This is why we emphasize the importance of the statistics used.

Two last points regarding statistics: 1) page 5-3 (1st para.) relates to off-site dispersion of radioactive materials and implies that such events are minimized by wet weather conditions. The failing here is to analyze for the worst case, for example, hot dry windy conditions. 2) As admitted in the report, dosage over time is a very important consideration. The NRC has rules covering the control of extreme dosing, but this document dismissed this with a statement that plans to control this are in the works, and more importantly, that the probability of heavy dosage are negligible. Setting the mathematical models aside, EPA feels that the regulations should be the issue here, namely adherence to them. The plans to do this need to be addressed in the Final EIS. EPA-5

2. Cladding Technology:

The first line of safety in the reactor is the cladding system surrounding the uranium and its fission products. From what we gather this is shelf technology or at least state of the art, but the description on page 4-11 of the SER (NUREG 0991) is not very reassuring with regard for the documentaion of control technology for waterside corrosion. As we understand it, this is a minor and fairly well recognized problem, but has yet to be completely nailed down with regard for both causes and cures, although operational regulations probably minimize any hazards. The Final EIS should pay some attention to detailing the status of this problem and current efforts to pin point it and correct it. Could this, as discussed above, ever exacerbate a minor event such as unexpected shut-down of cooling systems with associated pressure or loss rise? EPA-6

3. Benefits:

Page 6-3 relates the benefits to be realized from operation of the two units. Presumably these benefits will accrue to the consumer, although this is not stated in the text, and they amount to $34 million (1985 dollars). How is this figure reconciled with PECO's recent statement that they will petition the Pennsylvania Utility Commission in spring of '84 for a 20% rate raise to cover costs associated with unit one and for another rate raise of 20% in '85 to cover the cost of unit 2? Translated into current dollars, the initial request will amount to $477 million cost to the consumers. Perhaps NRC should carry out an analysis of conventionally fueled power production so that the benefits claimed will be put into a EPA-7 better comparative perspective.

In addition, the decommissioning costs appear to be underestimated, even though set in a large range. Following the logic associated with the escalating costs of construction, it would seem that decommissioning should follow the same path.

4. Evacuation Plans:

Evacuation plans are mentioned on page 5-12 as incomplete, but in preparation. Response systems are hardly mentioned, and then in only a generic way. The Final EIS should present these in full detail, with a full disclosure of how it was related and explained to the subject population prior to Final EIS. This must be done prior to completing the final EIS because a major objective is to assure the safety in times of accident. This may have an ancillary positive effect in that people in the area will soon come to realize that the plant operators and NRC really care about the concerns of the local populace. EPA-8

Miscellaneous

On page 5-7, it is stated, and presumably attributed to the National Research Council and to Land, that "...(radiation has) been studied more exhaustively than any other environmental contaminent." This kind of majestic statement, regardless of who makes it, is highly controversial and has no place in a document of this kind. Even if it does not over state the case, it says something about a technology that feels compelled to make it. EPA-9

The fourth paragraph on the same page refers to the questionable fact that "Most authorities agree..." on the statistics regarding health effects of radiation from such plants. It is suggested that NRC rely upon specific citations rather than inexact and unspecified references. On the whole, the document reflects a great deal of highly sophisticated mathematical manipulation, but NRC would do well to recognize that "...chaos results when design is assumed to be primarily a problem in mathematics." (E.S.Furguson, Sci. 26, Aug. '77). Attention should also be given to non-design factors and public awareness. EPA-10

The review coordinator tried to contact the appropriate people at NRC to discuss some of the points raised in this letter, but was unable to do so in a timely fashion and faced with the deadline. Therefore, some of the points raised here may either have been either already dealt with by the NRC staff or are amenable to easy explanation.

PHILADELPHIA ELECTRIC COMPANY
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PHILADELPHIA, PA. 19101
(215) 841-4500

V. S. BOYER
SR. VICE PRESIDENT
NUCLEAR POWER

February 6, 1984

Mr. Darrell G. Eisenhut, Director
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: NUREG-0974 Supplement No. 1: Draft Environmental Statement Related to the Operation of Limerick Generating Station, Units 1 and 2, Docket Nos. 50-352 and 50-353

Dear Mr. Eisenhut:

We have reviewed the subject supplement to the Limerick DES. A summary of our major comments and concerns are provided below and detailed comments are attached.

OVERALL

We have performed and presented in the Severe Accident Risk Assessment (SARA) a full scope probabilistic risk assessment of the Limerick Generating Station. This analysis included the effects of internal and external initiating events and an extensive analysis of uncertainties. We concur with the staff's conclusions that "accident risks from Limerick are expected to be a small fraction of the risks the general public incurs from other sources". However, it is Philadelphia Electric Company's position that inappropriately large conservatisms have been incorporated in the DES analysis. We believe that the SARA analysis provides a more realistic assessment of the risks. PECo-1

SOURCE TERMS AND UNCERTAINTY

Some of the source terms in the DES are higher than any in prior environmental statements, probabilistic risk assessments, or source term analyses. They are also higher than those estimated in the SARA. The use of such large source terms contributes to calculated consequences that are essentially upper bounds. It would, therefore, appear to be unnecessary to include additional quantitative uncertainty or sensitivity analysis. PECo-2

SOURCE TERMS AND UNCERTAINTY (continued)

Since any quantification of uncertainty must include consideration of the level of conservatism in the analysis, we view the DES presentation of quantified uncertainties as inappropriate and unnecessary. This derives from our belief, reinforced by the SARA analysis, that the DES results are upper bounds and that while the NRC's NEPA policy statement requires identification of major uncertainties it does not require quantitative uncertainty analyses.

MEAN VS. MEDIAN

NUREG-0880 "Safety Goals for Nuclear Power Plant Operation" specifies the use of median values for probabilistic risk calculations. The SARA analysis presented the results as medians due to our agreement with the view that median values are more appropriate than means. The SARA analysis also provided point estimates for completeness. Most previous staff environmental statement assessments of risk (Susquehanna, Fermi 2, Byron) have utilized median frequencies. The Limerick DES departs from this practice. PECo-3

NUREG/CR-3028

The staff has used the NUREG/CR-3028 point estimates, which we believe are incorrect, for internal events in the DES analysis. Four issues, identified to the staff at our meeting of September 26, 1983 (reference 1 of attachment), have not been addressed by the DES. These issues are: Recovery of Feedwater, Loss of Offsite Power Initiator Frequency, HPCI Restart Failure Probability, and Failure of Manual Depressurization. PECo-4

We believe that the Severe Accident Risk Assessment (SARA) represents a realistic assessment, including uncertainties, of the public risk due to potential accidents at the Limerick Generating Station and fulfills the requirements of NEPA in regard to their realistic portrayal. An alternative to the use of SARA in the FES would be to use the conservative source terms shown in the DES but to delete the quantitative display of uncertainties from the FES and to explicitly note the conservatism in that approach. PECo-5

Enclosure

See Attached Service List

V. S. Boyer

cc: Judge Lawrence Brenner	(w/enclosure)
Judge Peter A. Morris	(w/enclosure)
Judge Richard F. Cole	(w/enclosure)
Troy B. Conner, Jr., Esq.	(w/enclosure)
Ann P. Hodgdon, Esq.	(w/enclosure)
Mr. Frank R. Romano	(w/enclosure)
Mr. Robert L. Anthony	(w/enclosure)
Mr. Marvin I. Lewis	(w/enclosure)
Ms. Phyllis Zitzer	(w/enclosure)
Charles W. Elliott, Esq.	(w/enclosure)
Zori G. Ferkin, Esq.	(w/enclosure)
Mr. Thomas Gerusky	(w/enclosure)
Director, Pennsylvania Emergency Management Agency	(w/enclosure)
Mr. Steven P. Hershey	(w/enclosure)
Angus Love, Esq.	(w/enclosure)
Mr. Joseph H. White, III	(w/enclosure)
David Wersan, Esq.	(w/enclosure)
Robert J. Sugarman, Esq.	(w/enclosure)
Martha W. Bush, Esq.	(w/enclosure)
Spence W. Perry, Esq.	(w/enclosure)
Jay M. Gutierrez, Esq.	(w/enclosure)
Atomic Safety and Licensing Appeal Board	(w/enclosure)
Atomic Safety and Licensing Board Panel	(w/enclosure)
Docket and Service Section	(w/enclosure)

COMMENTS

ON

NUREG-0974

SUPPLEMENT NO. 1

DRAFT ENVIRONMENTAL STATEMENT

RELATED TO THE OPERATION OF

LIMERICK GENERATING STATION

UNITS 1 AND 2

DOCKET NOS. 50-352 AND 50-353

CHAPTER/SECTION
SUMMARY AND CONCLUSION

Page v — Item (1): We concur with the conclusion of this item and believe that the substantial conservatisms introduced by the staff strongly reinforce that conclusion.

ENVIRONMENTAL CONSEQUENCES AND MITIGATING ACTIONS

Page 5-4 and 5-5 — Table 5.11a: The assumed power level of 3458 MWth is not consistent with the actual full power license limit of 3293 MWth. PECo-6

Table 5.11a: The values for radioactive inventory differ from those appropriate for Limerick by ratios ranging from .49 to 1.92. The appropriate Limerick inventory is as shown in Table 7.1-24 of the EROL, Table E.8 of the PRA, or Table 10-1 of SARA (See also comments on pages 5-16 and N-2). PECo-7

Page 5-15 — Section 5.9.4.5(2), top line: It should be noted that the source terms are conservatively treated in the DES analysis contrary to the "improvements" suggested by this statement. PECo-8

Section 5.9.4.5(2), third full paragraph, third sentence: This is a very conservative assumption in the source term development, considering the advances made in this area since publication of WASH-1400. It is recognized that this is currently an ongoing subject of research but this approach is overly conservative and ignores the Limerick

-1-

specific source term analysis of NUREG/CR-3028, the LGS-PRA, or SARA. It is noted that the source terms are more extreme than those considered possible in the SARA sensitivity analysis or used in previous staff ES analysis.

Page 5-16 Section 5.9.4.5(2), first full paragraph, first sentence: The use of mean values is inconsistent with previous DES/FES analyses by the staff which have used median frequencies. The representation of sequence frequencies for LGS is therefore more conservative than other ES analyses. PECo-9

Section 5.9.4.5(2), first full paragraph, third and fourth sentences: The use of an effective peak ground acceleration of 0.4g as the dividing line between severe earthquakes and earthquakes of low to medium severity is conservative. At that level of acceleration there would likely be only a small number of, if any, bridge or overpass failures, and complete disruption of the road network is not expected. The "Late Reloc" mode of evacuation (see comment on p. 5-21, third paragraph), in which it is assumed that people are relocated after 24 hours, is excessively conservative for earthquakes in the 0.4g acceleration range. The SARA figure of 0.61g (SARA page 10-14) for severe disruption of the road network is more realistic. The staff provides no justification for the assumption that, in the event of a severe earthquake, it would be impossible to evacuate anybody for at least 24 hours. This topic was discussed in our August 29, 1983 submittal (PECo reply to Geosciences Question Q7). PECo-10 PECo-11

Section 5.9.4.5(2), third full paragraph, second sentence: Inventory is inappropriate for a BWR (See comments on Table 11.a above and page N-2 below). PECo-12

Page 5-17 Table 5.11c: Changes made from the SARA analysis are significant and result in increased conservatism of the staff results. PECo-13

Some source terms in the DES are higher than any in the RSS, e.g., 94-96% iodine compared with a maximum of 90% in sequence BWR2 (RSS Table VI 2-1); 86-87% cesium compared with a maximum of 50% in the RSS. For previous BWR FES's, rebaselined WASH-1400 source terms were utilized with the largest source term was TC γ' with 45% iodine, 67% cesium and 64% tellurium). Further, steam explosion source terms containing 40-50% ruthenium can only come about in PECo-14 PECo-15 PECo-16

-2-

the event that 50% or more of the core is involved in a steam explosion. Such steam explosions were not considered in earlier FES's (see, for example, Susquehanna FES Table 6.1.4-2). Therefore, the LGS has been treated more pessimistically than other BWRs in previous FES's. In summary, the use of the RSS methodology in the DES is very conservative. PECo-17

Page 5-18 Table 5.11d: From inspection of the frequency values it is apparent that changes in the containment event trees for hydrogen burn, steam explosion and SGTS operation from the LGS-PRA or NUREG/CR-3028 have been made. The changes and their bases have not been provided. For Class II and Class III, the DW and WW failure modes were combined with the WW failure since the staff assumed a pool decontamination factor of one for saturated pools. This yields a conservative evaluation. PECo-18

The frequency differences are substantial and are due to the staff not correcting the BNL assessment (NUREG/CR-3028) of the LGS-PRA and the selection of .4g as the breakpoint (see comments on page 5-16 and N-3). Correction of the values per comments previously provided (see reference 1) and using the more realistic .61g would reduce risk estimates substantially and reinforce the conclusions of the DES. PECo-19

Page 5-21 Section 5.9.4.5(2), second paragraph: The use of a single delay time (2 hr) is not as realistic as the model used in SARA (Table 10-8, with a 1, 3, or 5 hour delay time). The DES (p. N-2) criticizes the SARA model because it is "not site specific". However, the staff has used the same model in other FES' (e.g., Susquehanna, NUREG-0564). PECo-20

Section 5.9.4.5(2), third paragraph, first sentence: Limiting the ability to effectively evacuate is not unreasonable, but assuming no evacuation for the population around the site is overly conservative. PECo-21

Page 5-23 Section 5.9.4.5(2), third paragraph and ** note: The DES utilized mean frequencies for the various accident sequences and categories rather than medians. The mean for a positively skewed distribution such as the log normal corresponds to a confidence level well above the median and could correspond to confidence levels as high as 80-90 percent. The median which represents the value where there is an equal likelihood of being greater PECo-22 or less is considered to be a more appropriate measure of risk. Most previous environmental assessments of risk (Susquehanna, Fermi 2, Byron) utilized median frequencies in their analysis rather than means. While the impact of this is small for internal initiators it is large for the seismic initiators where the mean is almost a factor of 20 higher than the median.

Page 5-25 through 5-31

Figures 5.4b to 5.4g and Table 5.11g: The results shown are more severe than presented in the LGS SARA. This is due to the higher frequencies, higher release fractions, and more pessimistic emergency response. The major difference is in the CCDF for early fatalities (Figure 5.4e) which lies above the upper 95% curve from SARA. The represented upper confidence levels (cross hatched areas) are not substantiated and are unprecedented for any assessment of risk. It is difficult to believe that these are plausible outcomes at any but the most extreme (much greater than 99%) confidence levels. PECo-23

The early fatality risk associated with Limerick, based on this analysis, is dominated by extreme seismic events of rare occurrence. It is particularly important to point out that the postulated seismic event in addition to inflicting damage on the Limerick site would cause substantially higher fatalities directly to the population (through falling debris, building structural failures, etc.) than are attributed to Limerick related causes. Regardless of Limerick operation, substantial risk to the population exists from large magnitude seismic events. This issue can be addressed if the risk to the population associated with a large magnitude seismic event is displayed along with the incremental risk associated with such an event during Limerick operation. It would then be apparent that the <u>incremental risk</u> of Limerick operation would be negligible. PECo-24

Page 5-48

Section 5.9.4.5(7) <u>Probability of Occurrence of Accident</u>: No mention of the differences between the PRA and the BNL review (NUREG/CR-3028) is made. The points made at the 9/26/83 meeting (reference 1) regarding the BNL reassessment would lower the BNL core melt frequency by 7.3×10^{-5}. PECo-25

Section 5.9.4.5(7) <u>Probability of Occurrence of Accident</u> second paragraph, fifth sentence: The criticism of the use of 95% and 5% is a matter of PECo-26

-4-

semantics. The 95% and 5% limits are used in SARA to represent a range of frequencies which incorporates a large part of the uncertainties.

Section 5.9.4.5(7): Probability of Occurrence of Accident, second paragraph, sixth sentence: This statement is not clear as to intent. The staff's analysis uses only a point estimate. The EROL (SARA) does consider the uncertainty in seismic probability in detail in making its assessment. The DES provides no adequate justification for its use of point estimates, particularly in the seismic events. PECo-27

Page 5-49 Section 5.9.4.5(7), first full paragraph: A comparison is made of the DES core melt probability with published PRAs. This is inconsistent and presents an unfair comparison because the values for other plants are from the published PRA's not from staff or staff contractor reviews. PECo-28

Section 5.9.4.5(7), second full paragraph, fifth sentence: The staff has disregarded the Limerick specific analysis contained in NUREG/CR-3028, the LGS-PRA, or SARA with regard to source terms development. PECo-29

Page 5-52 Section 5.9.4.5(7), fifth full paragraph: The meteorological sampling scheme used in CRAC is mentioned as a source of uncertainty. CRAC2, which was used in SARA, was specifically developed to reduce this uncertainty (see Procedures Guide p. 9-92). PECo-30

Page 5-56 to 5-60 Figures 5.4n, o, p, q, r: The uncertainty bounds, contradict the text on page 5-54, which states that "the risk uncertainty bounds could be well over a factor of 10, but not as large as a factor of 100. Within these uncertainty bounds, however, the uncertainties associated with the probability-integrated values of consequences (the risks) are likely to be less. . .". No explanation is provided of what the uncertainty bounds represent. They appear to be an arbitrary factor of 100 in all cases. It is expected that the point estimate represents something greater than a 50% confidence level and may be greater than the 90% confidence level in some cases. It is believed that the weight of evidence supports a realistic estimate of risk considerably lower than the DES values and that the DES point estimates are much nearer the upper estimate than the median. PECo-31

EVALUATION OF THE PROPOSED ACTION

Page 6-1	Table 6.1, the reduction in generating costs of $34 million/unit/year presented and discussed in Section 6.4.2 (page 6-3) underestimates the operating savings attributable to Limerick. As presented in EROL Table E320.1-1 (Revision 15, August 1983), the operational savings should be $188.8 million in 1986 for single unit operation.	PECo-32

APPENDIX H

General	Risk important source terms utilized by the staff are higher than those used in any other assessment to which the staff compares results. The source terms have a substantial impact on the risk. While the staff acknowledges that the source terms are probably conservative (". . .source terms used in the staff analysis cannot be much higher in the maximum, but could be substantially lower."; page 5-51) the impact of this is not assessed nor considered.	PECo-33
Page H-1	Second paragraph, fifth sentence: More is known about fission product release and transport than was known at the time of the Reactor Safety Study; where the values used were very conservative in the absence of knowledge. The staff conservatism tends to make the analysis an upper bound rather than a realistic point estimate. It should also be pointed out that the source terms are higher than past ES analyses by the staff.	PECo-34
Page H-2	Second full paragraph: It is extremely conservative to use a DF of one for a saturated pool. The applicability of a DF of greater than one for a saturated pool has been well established by experiment (reference 2, 3, and 4).	PECo-35

APPENDIX J

General	The DES assumptions for emergency response modeling are a limited set of the possible responses. SARA considered a more comprehensive set.	PECo-36

APPENDIX N

Page N-1	Comparisons of CRAC and CRAC2 in the international benchmark exercises produced results that are quite close. However, the meteorological sampling scheme used in CRAC leads to much greater uncertainties than in CRAC2, see Figure 9-17 of the PRA Procedures Guide.	PECo-37

Page N-2 Second full paragraph: We have two concerns with the calculation of core inventory. The first is that the use of 105% power is inconsistent with the application to a probabilistic analysis. A power level of 105% is strictly a design basis assumption and is not a best estimate of the actual power level for Limerick. Secondly, the DES used an inventory developed for a PWR by a code (ORIGEN) which was designed for another purpose. The LGS-PRA utilized the code RADCINDER for a BWR core (See response to Question E.01(b) page Q-126, Vol. 1 of the LGS-PRA). PEC.-38

Page N-5 First paragraph, sixth sentence: The staff criticizes the SARA because there are "too many variations in the optimistic direction for nonsevere earthquake conditions," as one of the factors leading to suspicions that "the upper estimates of the overall CCDFs in the EROL are biased". However, optimistic sensitivity studies in SARA were used to fix the lower estimate and had no effect on the upper estimate. PEC.-39

First paragraph, sixth sentence: The staff criticizes the SARA analysis for not varying source terms to encompass some of the high values of the release fractions used in the staff analyses. PECo-40 However, as noted in the foregoing discussion of the DES source terms, we believe that the DES source terms are highly conservative. We also believe that the largest source term in SARA, VRH20, is conservative because radionuclide retention in the primary coolant system and reactor enclosure was neglected. Therefore, we consider that, if criticism is to be leveled at the SARA and EROL source terms, it should be because these source terms are too high rather than too low. PECo-41

<u>Comment References</u>

(1) R. E. Martin, dated: December 9, 1983, Subject: Summary of Severe Accident Risk Assessment Review Meeting held on September 26, 1983. With attachments.

(2) Rastler, D. M., 1981. <u>Suppression Pool Scrubbing Factors for Postulated Boiling Water Reactor Accident Conditions, General Electric Company</u>, NEDO-25420, Class 1.

(3) Marble, W. J., et. al., 1982. "Retention of Fission Products by BWR Suppression Pools During Severe Accidents", paper presented at

the ANS Meeting on Thermal Reactor Safety, August 30th - September 2, 1982, Chicago, Ill.

(4) SARA, Philadelphia Electric Company, 1983, Section E2.6.1 and Table E-4.

Pennsylvania Intergovernmental Council

P. O. BOX 1288 • HARRISBURG, PA. 17108 • (717) 783-3700

February 6, 1984

A. Schwencer, Chief
Licensing Branch No. 2
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Schwencer:

Subject: Supplement No. 1 to the Draft Environmental Statement - Limerick Generating Station, Units 1 and 2

PIC

Pennsylvania's Single Point of Contact under Executive Order 12372 (Intergovernmental Review of Federal Programs) has received ten copies of Supplement No. 1 to the Draft Environmental Statement - Limerick Generating Station, Units 1 and 2. We forwarded a copy to the Pennsylvania Department of Environmental Resources for review and comment. Although we received no specific comments from this Department, they did forward comments they had received from the Pennsylvania Department of Health. These comments are enclosed for your information.

We appreciate the opportunity to review this document.

Sincerely,

Barbara J. Gontz

Barbara J. Gontz
Project Coordinator
Intergovernmental Review Process

BJG/klm

Enclosure

Strengthening Intergovernmental Relations and Public Decision-making in Pennsylvania

12-67
RLY OA-5011

COMMONWEALTH OF PENNSYLVANIA

(717) 787-1708
January 18, 1984

SUBJECT: EIS - Limerick Generating Station Units 1 and 2

TO: Department of Environmental Resources
Bureau of Policy Analysis
2nd Floor Fulton Bank Building

FROM: James N. Logue, Dr. P.H., M.P.H. JNL
Director
Division of Environmental Health

In our review, the Division focused attention on those portions of the document relating to possible health effects. The Division assumed that proper methodology was used in the evaluation of the environment, predictions of accidents, etc., discussed in other portions. The sections relating to health effects are very complex and some areas are not totally understandable (e.g. - Risk consideration). However, this Division, together with DOH's Division of Epidemiology Research, did review the document and offer the following statements:

1. Comparison of risks due to operation of the plant to risks due to other human daily activities suggests that the plant risks appear to be inconsequential.

2. Cancer risk, even in a "worst case" situation, appears acceptable. This judgement takes into consideration the fact that the chance of a severe case occurring is very remote.

3. As to safety, such as the evacuation scheme, we question how realistic this is. PIC-1

4. Since the Emergency Preparedness Plan is not completed or included for this specific site, it is difficult to evaluate the response to any type of accident that may occur at Limerick. This plan, it is noted, is required before a license can be issued. PIC-2

5. Basically we have no objections to the health effects, avoidance or impact sections of the document.

JNL:jew

cc: Dr. Hays
Dr. Logue
Dr. Fox
file

ER 83/1571

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

FEB 8 1984

Director, Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Sir:

The Department of the Interior has reviewed Supplement No. 1 to the draft environmental impact statement (OLS) for Limerick Generating Station, Units 1 and 2, Montgomery County, Pennsylvania, and has the following comments.

Supplement No. 1 addresses only the potential escape of radioactive byproducts into the environment from a nuclear accident and potential effects of such an escape on humans.

However, the consequences of severe accidents on the Schuylkill River are not made clear. Fallout on open water bodies is cited as a potential pathway for doses resulting from atmospheric releases but effects were not estimated specifically for this site, apparently because an investigation at another site found that these doses could be substantially eliminated by the "interdiction of the aquatic food pathway" (p. 5-33, par. 3). At the Limerick site this interdiction must be presumed to mean shutting off the water intakes on the Schuykill River serving about 1.9 million people downstream from the reactors. It would be important to know for how long the intakes must remain closed. To evaluate this, not only the fallout of radionuclides into open water but also the runoff of contaminated materials from the land must be considered. DOI-1

Potential adverse effects to fish and wildlife resources from exposure to radioactive materials are not considered. The Fish and Wildlife Service is supporting efforts by the Pennsylvania Fish Commission to restore anadromous fish runs to the Schuylkill River. The Schuylkill River also serves as a major flyway for raptors and waterfowl from central New York State and the Great Lakes. Effects of potential contamination on these fish and wildlife resources should also be considered. DOI-2

For information on fish and wildlife populations in the area of concern you may wish to contact the Pennsylvania Fish Commission (P.O. Box 1673, Harrisburg, Pennsylvania 17105; 717-787-2579) and the Pennsylvania Game Commission (P.O. Box 1567, Harrisburg, Pennsylvania 17120; 717-787-3633). For further assistance, please contact the Field Supervisor, U.S. Fish and Wildlife Service, 315 S. Allen Street, Suite 322, State College, Pennsylvania 16801 (814-234-4090 or FTS 727-4621).

We hope these comments will be helpful to you in the preparation of a final statement.

Sincerely,

Bruce Blanchard, Director
Environmental Project Review

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

Food and Drug Administration
Rockville MD 20857

FEB 1 0 1984

Albert Schwencer, Chief
Licensing Branch No. 2
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Schwencer:

FDA

The staff of the National Center for Devices and Radiological Health has no comment relevant to the Draft Environmental Statement (DES) concerning the postulated plant accidents at Limerick Generating Station Units 1 and 2 NUREG 0974 Supplement No. 1 December 1983.

Thank you for the opportunity to comment on the subject DES.

Sincerely yours,

John C. Villforth
Director
National Center for Devices
and Radiological Health

APPENDIX B

NEPA POPULATION-DOSE ASSESSMENT

APPENDIX B
NEPA POPULATION-DOSE ASSESSMENT

Population-dose commitments are calculated for all individuals living within 80 km (50 miles) of the Limerick facility, employing the same dose calculation models used for individual doses (see Regulatory Guide (RG) 1.109, Revision 1), for the purpose of meeting the "as low as reasonably achievable" (ALARA) requirements of 10 CFR 50, Appendix I. In addition, dose commitments to the population residing beyond the 80-km region, associated with the export of food crops produced within the 80-km region and with the atmospheric and hydrospheric transport of the more mobile effluent species, such as noble gases, tritium, and carbon-14, are taken into consideration for the purpose of meeting the requirements of the National Environmental Policy Act, 1969 (NEPA). This appendix describes the methods used to make these NEPA-population dose estimates.

1. Iodines and Particulates Released to the Atmosphere

Effluent nuclides in this category deposit onto the ground as the effluent moves downwind; thus the concentration of these nuclides remaining in the plume is continuously being reduced. Within 80 km of the facility, the deposition model in RG 1.111, Revision 1, is used in conjunction with the dose models in RG 1.109, Revision 1. Site-specific data concerning production and consumption of foods within 80 km of the reactor are used. For estimates of population doses beyond 80 km, it is assumed that excess food not consumed within the 80-km area would be consumed by the population beyond 80 km. It is further assumed that none, or very few, of the particulates released from the facility will be transported beyond the 80-km distance; thus, they will make no significant contribution to the population dose outside the 80-km region, except by export of food crops. This assumption was tested and found to be reasonable for the Limerick station.

2. Noble Gases, Carbon-14, and Tritium Released to the Atmosphere

For locations within 80 km of the reactor facility, exposures to these effluents are calculated with a constant mean wind-direction model according to the guidance provided in RG 1.111, Revision 1, and the dose models described in RG 1.109, Revision 1. For estimating the dose commitment from these radionuclides to the U.S. population residing beyond the 80-km region, two dispersion regimes are considered. These are referred to as the first-pass-dispersion regime and the world-wide-dispersion regime. The model for the first-pass-dispersion regime estimates the dose commitment to the population from the radioactive plume as it leaves the facility and drifts across the continental U.S. toward the northeastern corner of the U.S. The model for the world-wide-dispersion regime estimates the dose commitment to the U.S. population after the released radionuclides mix uniformly in the world's atmosphere or oceans.

(a) First-Pass Dispersion

For estimating the dose commitment to the U.S. population residing beyond the 80-km region as a result of the first pass of radioactive pollutants, it is assumed that the pollutants disperse in the lateral and vertical directions along the plume path. The direction of movement of the plume is assumed to be from the facility toward the northeast corner of the U.S. The extent of vertical dispersion is assumed to be limited by the ground plane and the stable atmospheric layer aloft, the height of which determines the mixing depth. The shape of such a plume geometry can be visualized as a right cylindrical wedge whose height is equal to the mixing depth. Under the assumption of constant population density, the population dose associated with such a plume geometry is independent of the extent of lateral dispersion, and is only dependent upon the mixing depth and other nongeometrical related factors (NUREG-0597). The mixing depth is estimated to be 1000 m, and a uniform population density of 62 persons/km^2 is assumed along the plume path, with an average plume-transport velocity of 2 m/s.

The total-body population-dose commitment from the first pass of radioactive effluents is due principally to external exposure from gamma-emitting noble gases, and to internal exposure from inhalation of air containing tritium and from ingestion of food containing carbon-14 and tritium.

(b) World-Wide Dispersion

For estimating the dose commitment to the U.S. population after the first-pass, world-wide dispersion is assumed. Nondepositing radionuclides with half-lives greater than 1 year are considered. Noble gases and carbon-14 are assumed to mix uniformly in the world's atmosphere (3.8×10^{18} m^3), and radioactive decay is taken into consideration. The world-wide-dispersion model estimates the activity of each nuclide at the end of a 20-year release period (midpoint of reactor life) and estimates the annual population-dose commitment at that time, taking into consideration radioactive decay and physical removal mechanisms (for example, carbon-14 is gradually removed to the world's oceans). The total-body population-dose commitment from the noble gases is due mainly to external exposure from gamma-emitting nuclides, whereas from carbon-14 it is due mainly to internal exposure from ingestion of food containing carbon-14.

The population-dose commitment as a result of tritium releases is estimated in a manner similar to that for carbon-14, except that after the first pass, all the tritium is assumed to be immediately distributed in the world's circulating water volume (2.7×10^{16} m^3) including the top 75 m of the seas and oceans, as well as the rivers and atmospheric moisture. The concentration of tritium in the world's circulating water is estimated at the time after 20 years of releases have occurred, taking into consideration radioactive decay; the population-dose commitment estimates are based on the incremental concentration at that time. The total-body population-dose commitment from tritium is due mainly to internal exposure from the consumption of food.

3. Liquid Effluents

Population-dose commitments due to effluents in the receiving water within 80 km of the facility are calculated as described in RG 1.109, Revision 1. It is assumed that no depletion by sedimentation of the nuclides present in the receiving water occurs within 80 km. It also is assumed that aquatic biota concentrate radioactivity in the same manner as was assumed for the ALARA evaluation for the maximally exposed individual. However, food-consumption values appropriate for the average, rather than the maximum, individual are used. It is further assumed that all the sport and commercial fish and shellfish caught within the 80-km area are eaten by the U.S. population.

Beyond 80 km, it is assumed that all the liquid-effluent nuclides except tritium have deposited on the sediments so that they make no further contribution to population exposures. The tritium is assumed to mix uniformly in the world's circulating water volume and to result in an exposure to the U.S. population in the same manner as discussed for tritium in gaseous effluents.

4. References

U.S. Nuclear Regulatory Commission, NUREG-0597, K. F. Eckerman, et al., "User's Guide to GASPAR Code," June 1980.

---, RG 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 1, October 1977.

---, RG 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Reactors," Revision 1, July 1977.

APPENDIX C

IMPACTS OF THE URANIUM FUEL CYCLE

APPENDIX C

IMPACTS OF THE URANIUM FUEL CYCLE

The following assessment of the environmental impacts of the LWR-supporting fuel cycle as related to the operation of the proposed project is based on the values given in Table S-3 of Title 10 of the Code of Federal Regulations, Part 50 (10 CFR 50) (see Section 5.10 of the main body of this report) and the NRC staff's estimates of radon-222 and technetium-99 releases. For the sake of consistency, the analysis of fuel-cycle impacts has been cast in terms of a model 1000-MWe light-water-cooled reactor (LWR) operating at an annual capacity factor of 80%. In the following review and evaluation of the environmental impacts of the fuel cycle, the staff's analysis and conclusions would not be altered if the analysis were to be based on the net electrical power output of the Limerick Nuclear Generating Station.

1. Land Use

The total annual land requirement for the fuel cycle supporting a model 1000-MWe LWR is about 460,000 m^2 (113 acres). Approximately 53,000 m^2 (13 acres) per year are permanently committed land, and 405,000 m^2 (100 acres) per year are temporarily committed. (A "temporary" land commitment is a commitment for the life of the specific fuel-cycle plant, such as a mill, enrichment plant, or succeeding plants. On abandonment or decommissioning, such land can be used for any purpose. "Permanent" commitments represent land that may not be released for use after plant shutdown and/or decommissioning.) Of the 405,000 m^2 per year of temporarily committed land, 320,000 m^2 are undisturbed and 90,000 m^2 are disturbed. Considering common classes of land use in the United States,* fuel-cycle land-use requirements to support the model 1000-MWe LWR do not represent a significant impact.

2. Water Use

The principal water-use requirement for the fuel cycle supporting a model 1000-MWe LWR is that required to remove waste heat from the power stations supplying electrical energy to the enrichment step of this cycle. Of the total annual requirement of 43 x 10^6 m^3 (11.4 x 10^9 gal), about 42 x 10^6 m^3 are required for this purpose, assuming that these plants use once-through cooling. Other water uses involve the discharge to air (for example, evaporation losses in process cooling) of about 0.6 x 10^6 m^3 (16 x 10^7 gal) per year and water discharged to the ground (for example, mine drainage) of about 0.5 x 10^6 m^3 per year.

On a thermal effluent basis, annual discharges from the nuclear fuel cycle are about 4% of those from the model 1000-MWe LWR using once-through cooling. The consumptive water use of 0.6 x 10^6 m^3 per year is about 2% of that from the

*A coal-fired plant of 1000-MWe capacity using strip-mined coal requires the disturbance of about 810,000 m^2 (200 acres) per year for fuel alone.

model 1000-MWe LWR using cooling towers. The maximum consumptive water use (assuming that all plants supplying electrical energy to the nuclear fuel cycle used cooling towers) would be about 6% of the model 1000-MWe LWR using cooling towers. Under this condition, thermal effluents would be negligible. The staff finds that these combinations of thermal loadings and water consumption are acceptable relative to the water use and thermal discharges of the proposed project.

3. Fossil Fuel Consumption

Electrical energy and process heat are required during various phases of the fuel-cycle process. The electrical energy is usually produced by the combustion of fossil fuel at conventional power plants. Electrical energy associated with the fuel cycle represents about 5% of the annual electrical power production of the model 1000-MWe LWR. Process heat is primarily generated by the combustion of natural gas. This gas consumption, if used to generate electricity, would be less than 0.3% of the electrical output from the model plant. The staff finds that the direct and indirect consumptions of electrical energy for fuel-cycle operations are small and acceptable relative to the net power production of the proposed project.

4. Chemical Effluents

The quantities of chemical, gaseous, and particulate effluents associated with fuel-cycle processes are given in Table S-3. The principal species are sulfur oxides, nitrogen oxides, and particulates. On the basis of data in a Council on Environmental Quality report (CEQ, 1976), the staff finds that these emissions constitute an extremely small additional atmospheric loading in comparison with the same emissions from the stationary fuel-combustion and transportation sectors in the U.S.; that is, about 0.02% of the annual national releases for each of these species. The staff believes that such small increases in releases of these pollutants are acceptable.

Liquid chemical effluents produced in fuel cycle processes are related to fuel-enrichment, -fabrication, and -reprocessing operations and may be released to receiving waters. These effluents are usually present in dilute concentrations such that only small amounts of dilution water are required to reach levels of concentration that are within established standards. The flow of dilution water required for specific constituents is specified in Table S-3. Additionally, all liquid discharges into the navigable waters of the U.S. from plants associated with the fuel-cycle operations will be subject to requirements and limitations set forth in the NPDES permit.

Tailings solutions and solids are generated during the milling process. These solutions and solids are not released in quantities sufficient to have a significant impact on the environment.

5. Radioactive Effluents

Radioactive effluents estimated to be released to the environment from reprocessing and waste-management activities and certain other phases of the fuel-cycle process are set forth in Table S-3. Using these data, the staff has calculated for 1 year of operation of the model 1000-MWe LWR, the 100-year environmental dose commitment* to the U.S. population from the LWR-supporting fuel cycle. Dose commitments are provided in this section for exposure to four categories of radioactive releases: (1) airborne effluents that are quantified in Table S-3 (that is, all radionuclides except radon-222 and technetium-99), (2) liquid effluents that are quantified in Table S-3 (that is, all radionuclides except technetium-99); (3) the staff's estimates of radon-222 releases; and (4) the staff's estimate of technetium-99 releases. Dose commitments from the first two categories are also described in a proposed explanatory narrative for Table S-3, which was published in the Federal Register on March 4, 1981 (46 FR 15154-15175).

Airborne Effluents

Population dose estimates for exposure to airborne effluents are based on the annual releases listed in Table S-3, using an environmental dose commitment (EDC) time of 100 years.* The computational code used for these estimates is the RABGAD code originally developed for use in the "Generic Environmental Impact Statement on the Use of Mixed Oxide Fuel in Light-Water-Cooled Nuclear Power Plants," GESMO (NUREG-0002, Chapter IV, Section J, Appendix A). Two generic sites are postulated for the points of release of the airborne effluents: (1) a site in the midwestern United States for releases from a fuel reprocessing plant and other facilities, and (2) a site in the western United States for releases from milling and a geological repository.

The following environmental pathways were considered in estimating doses: (1) inhalation and submersion in the plume during its initial passage; (2) ingestion of food; (3) external exposure from radionuclides deposited on soil; and (4) atmospheric resuspension of radionuclides deposited on soil. Radionuclides released to the atmosphere from the midwestern site are assumed to be transported with a mean wind speed of 2 m/sec over a 2413-km (1500-mile)** pathway from the midwestern United States to the northeast corner of the United States, and deposited on vegetation (deposition velocity of 1.0 cm/sec) with subsequent uptake by milk- and meat-producing animals. No removal mechanisms are assumed during the first 100 years, except normal weathering from crops to soil (weathering half-life of 13 days). Doses from exposure to carbon-14 were estimated using the GESMO model to estimate the dose to U.S. population from the initial passage of carbon-14 before it mixed in the world's carbon pool. The model developed by Killough (1977) was used to estimate doses from exposure to carbon-14 after it mixed in the world's carbon pool.

In a similar manner, radionuclides released from the western site were assumed to be transported over a 3218-km (2000-mile) pathway to the northeast corner of the United States. The agricultural characteristics that were used in computing doses from exposure to airborne effluents from the two generic sites are described in GESMO (NUREG-0002, page IV J(A)-19). To allow for an increase in population, the population densities used in this analysis were 50% greater than the values used in GESMO (NUREG-0002, page IV J(A)-19).

*The 100-year environmental dose commitment is the integrated population dose for 100 years; that is, it represents the sum of the annual population doses for a total of 100 years.

**Here and elsewhere in this narrative, insignificant digits are retained for purposes of internal consistency in the model.

Liquid Effluents

Population dose estimates for exposure to liquid effluents are based on the annual releases listed in Table S-3 and the hydrological model described in GESMO (NUREG-0002, pages IV J(A)-20, -21, and -22). The following environmental pathways were considered in estimating doses: (1) ingestion of water and fish; (2) ingestion of food (vegetation, milk, and beef) that had been produced through irrigation; and (3) exposure from shoreline, swimming, and boating activities.

It is estimated from these calculations that the overall total-body dose commitment to the U.S. population from exposure to gaseous releases from the fuel cycle (excluding reactor releases and the dose commitment due to radon-222 and technetium-99) would be approximately 450 person-rems to the total body for each year of operation of the model 1000-MWe LWR (reference reactor year, or RRY). Based on Table S-3 values, the additional total-body dose commitments to the U.S. population from radioactive liquid effluents (excluding technetium-99) as a result of all fuel-cycle operations other than reactor operation would be about 100 person-rems per year of operation. Thus, the estimated 100-year environmental dose commitment to the U.S. population from radioactive gaseous and liquid releases due to these portions of the fuel cycle is about 550 person-rems to the total body (whole body) per RRY.

Because there are higher dose commitments to certain organs (for example, lung, bone, and thyroid) than to the total body, the total risk of radiogenic cancer is not addressed by the total body dose commitment alone. Using risk estimators of 135, 6.9, 22, and 13.4 cancer deaths per million person-rems for total-body, bone, lung, and thyroid exposures, respectively, it is possible to estimate the total body risk equivalent dose for certain organs (NUREG-0002, Chapter IV, Section J, Appendix B). The sum of the total body risk equivalent dose from those organs was estimated to be about 100 person-rems. When added to the above value, the total 100-year environmental dose commitment would be about 650 person-rems (total body risk equivalent dose) per RRY (Section 5.9.3.1.1 describes the health effects models in more detail).

Radon-222

At this time the quantitites of radon-222 and technetium-99 releases are not listed in Table S-3. Principal radon releases occur during mining and milling operations and as emissions from mill tailings, whereas principal technetium-99 releases occur from gaseous diffusion enrichment facilities. The staff has determined that radon-222 releases per RRY from these operations are as given in Table C-1. The staff has calculated population-dose commitments for these sources of radon-222 using the RABGAD computer code described in Volume 3 of NUREG-0002 (Appendix A, Chapter IV, Section J). The results of these calculations for mining and milling activities prior to tailings stabilization are listed in Table C-2.

The staff has considered the health effects associated with the releases of radon-222, including both the short-term effects of mining and milling and active tailings, and the potential long-term effects from unreclaimed open-pit mines and stabilized tailings. The staff has assumed that after completion of active mining, underground mines will be sealed, returning releases of radon-222

Table C-1 Radon releases from mining and milling operations and mill tailings for each year of operation of the model 1000-MWe LWR*

Radon source	Quantity released
Mining**	4060 Ci
Milling and tailings*** (during active mining)	780 Ci
Inactive tailings*** (before stabilization)	350 Ci
Stabilized tailings*** (several hundred years)	1 to 10 Ci/year
Stabilized tailings*** (after several hundred years)	110 Ci/year

*After 3 days of hearings before the Atomic Safety and Licensing Appeal Board (ASLAB) using the Perkins record in a "lead case" approach, the ASLAB issued a decision on May 13, 1981 (ALAB-640) on the radon-222 release source term for the uranium fuel cycle. The decision, among other matters, produced new source term numbers based on the record developed at the hearings. These new numbers did not differ significantly from those in the Perkins record, which are the values set forth in this table. Any health effects relative to radon-222 are still under consideration before the ASLAB. Because the source term numbers in ALAB-640 do not differ significantly from those in the Perkins record, the staff continues to conclude that both the dose commitments and health effects of the uranium fuel cycle are insignificant when compared to dose commitments and potential health effects to the U.S. population resulting from all natural background sources. Subsequent to ALAB-640, a second ASLAB decision (ALAB-654, issued September 11, 1981) permits intervenors a 60-day period to challenge the Perkins record on the potential health effects of radon-222 emissions

**R. Wilde, NRC transcript of direct testimony given "In the Matter of Duke Power Company (Perkins Nuclear Station)," Docket No. 50-488, April 17, 1978.

***P. Magno, NRC transcript of direct testimony given "In the Matter of Duke Power Company (Perkins Nuclear Station)," Docket No. 50-488, April 17, 1978.

to background levels. For purposes of providing an upper bound impact assessment, the staff has assumed that open-pit mines will be unreclaimed and has calculated that if all ore were produced from open-pit mines, releases from them would be 110 Ci per RRY. However, because the distribution of uranium-ore reserves available by conventional mining methods is 66% underground and 34% open pit (Department of Energy, 1978), the staff has further assumed that uranium to fuel LWRs will be produced by conventional mining methods in these proportions. This means that long-term releases from unreclaimed open-pit mines will be 0.34 x 110 or 37 Ci per year per RRY.

Table C-2 Estimated 100-year environmental dose commitment per year of operation of the model 1000-MWe LWR

Radon source	Radon-222 releases (Ci)	Environmental dose commitments: Total body (person-rems)	Bone (person-rems)	Lung (bronchial epithelium) (person-rems)	Total body risk equivalent dose (person-rems)
Mining	4100	110	2800	2300	630
Milling and active tailings	1100	29	750	620	170
Total	5200	140	3600	2900	800

Based on a value of 37 Ci per year per RRY for long-term releases from unreclaimed open-pit mines, the radon released from unreclaimed open-pit mines over 100- and 1000-year periods would be about 3700 Ci and 37,000 Ci per RRY, respectively. The environmental dose commitments for a 100- to 1000-year period would be as shown in Table C-3.

Table C-3 Estimated 100-year environmental dose commitments from unreclaimed open-pit mines for each year of operation of the model 1000-MWe LWR

Time span (years)	Radon-222 releases (Ci)	Environmental dose commitments: Total body (person-rems)	Bone (person-rems)	Lung (bronchial epithelium) (person-rems)	Total body risk equivalent dose (person-rems)
100	3,700	96	2,500	2,000	550
500	19,000	480	13,000	11,000	3,000
1,000	37,000	960	25,000	20,000	5,500

These commitments represent a worst case situation in that no mitigating circumstances are assumed. However, state and Federal laws currently require reclamation of strip and open-pit coal mines, and it is very probable that similar reclamation will be required for open-pit uranium mines. If so, long-term releases from such mines should approach background levels.

For long-term radon releases from stabilized tailings piles, the staff has assumed that these tailings would emit, per RRY, 1 Ci per year for 100 years, 10 Ci per year for the next 400 years, and 100 Ci per year for periods beyond 500 years. With these assumptions, the cumulative radon-222 release from stabilized-tailings piles per RRY would be 100 Ci in 100 years, 4090 Ci in 500 years, and 53,800 Ci in 1000 years (Gotchy, 1978). The total-body, bone, and bronchial epithelium dose commitments for these periods are as shown in Table C-4.

Table C-4 Estimated 100-year environmental dose commitments from stabilized-tailings piles for each year of operation of the model 1000-MWe LWR

		Environmental dose commitments			
Time span (year)	Radon-222 releases (Ci)	Total body (person-rems)	Bone (person-rems)	Lung (bronchial epithelium) (person-rems)	Total body risk equivalent dose (person-rems)
100	100	2.6	68	56	15
500	4,090	110	2,800	2,300	630
1,000	53,800	1,400	37,000	30,000	8,200

Using risk estimators of 135, 6.9, and 22 cancer deaths per million person-rems for total-body, bone, and lung exposures, respectively, the estimated risk of cancer mortality resulting from mining, milling, and active-tailings emissions of radon-222 (that is, Table C-2) is about 0.11 cancer fatality per RRY. When the risks from radon-222 emissions from stabilized tailings and from reclaimed and unreclaimed open-pit mines are added to the value of 0.11 cancer fatality, the overall risks of radon-induced cancer fatalities per RRY are as follows:

0.19 fatality for a 100-year period
2.0 fatalities for a 1000-year period

These doses and predicted health effects have been compared with those that can be expected from natural-background emissions of radon-222. Using data from the National Council on Radiation Protection (NCRP, 1975), the staff calculates the average radon-222 concentration in air in the contiguous United States to be about 150 pCi/m^3, which the NCRP estimates will result in an annual dose to the bronchial epithelium of 450 millirems. For a stabilized future U.S. population of 300 million, this represents a total lung-dose commitment of 135 million person-rems per year. Using the same risk estimator of 22 lung-cancer fatalities per million person-lung-rems used to predict cancer fatalities for the model 1000-MWe LWR, the staff estimates that lung-cancer fatalities alone from background radon-222 in the air can be calculated to be about 3000 per year, or 300,000 to 3,000,000 lung-cancer deaths over periods of 100 to 1000 years, respectively.

Current NRC regulations (10 CFR 40, Appendix A) require that an earth cover not less than 3 meters in depth be placed over tailings to reduce the Rn-222 emanation from the disposed tailings to less than 2 pCi/m^2-sec, on a calculated basis above background. In October 1983, the U.S. Environmental Protection Agency (EPA) published environmental standards for the disposal of uranium and thorium mill tailings at licensed commercial processing sites (EPA 1983). The EPA regulations (40 CFR 192) require that disposal be designed to limit Rn-222 emanation to less than 20 pCi/m^2-sec, averaged over the surface of the disposed tailings. The NRC Office of Nuclear Material Safety and Safeguards is reviewing its regulations for tailings disposal to ensure that they conform with the EPA regulations. Although a few of the dose estimates in this appendix would change if NRC adopts EPA's higher Rn-222 flux limit for disposal of tailings, the basic conclusion of this appendix should still be valid. That conclusion is: "The staff concludes that both the dose commitments and health effects of the LWR-supporting uranium fuel cycle are very small when compared with dose commitments and potential health effects to the U.S. population resulting from all natural-background sources."

Technetium-99

The staff has calculated the potential 100-year environmental dose commitment to the U.S. population from the release of technetium-99. These calculations are based on the gaseous and the hydrological pathway model systems described in Volume 3 of NUREG-0002 (Chapter IV, Section J, Appendix A) and are described in more detail in the staff's testimony at the operating license hearing for the Susquehanna Station (Branagan and Struckmeyer, 1981). The gastrointestinal tract and the kidney are the body organs that receive the highest doses from exposure to technetium-99. The total body dose is estimated at less than 1 person-rem per RRY and the total body risk equivalent dose is estimated at less than 10 person-rems per RRY.

Summary of Impacts

The potential radiological impacts of the supporting fuel cycle are summarized in Table C-5 for an environmental dose commitment time of 100 years. For an environmental dose commitment time of 100 years, the total body dose to the U.S. population is about 790 person-rems per RRY, and the corresponding total body risk equivalent dose is about 2000 person-rems per RRY. In a similar manner, the total body dose to the U.S. population is about 3000 person-rems per RRY, and the corresponding total body risk equivalent dose is about 15,000 person-rems per RRY using a 1000-year environmental dose commitment time.

Multiplying the total body risk equivalent dose of 2000 person-rems per RRY by the preceding risk estimator of 135 potential cancer deaths per million person-rems, the staff estimates that about 0.27 cancer death per RRY may occur in the U.S. population as a result of exposure to effluents from the fuel cycle. Multiplying the total body dose of 790 person-rems per RRY by the genetic risk estimator of 258 potential cases of all forms of genetic disorders per million person-rems, the staff estimates that about 0.20 potential genetic disorder per RRY may occur in all future generations of the population exposed during the 100-year environmental dose commitment time. In a similar manner, the staff estimates that about 2 potential cancer deaths per RRY and about 0.8 potential genetic disorder per RRY may occur using a 1000-year environmental dose commitment time.

Some perspective can be gained by comparing the preceding estimates with those from naturally occurring terrestrial and cosmic-ray sources. These average about 100 millirems. Therefore, for a stable future population of 300 million persons, the whole-body dose commitment would be about 30 million person-rems per year, or 3 billion person-rems and 30 billion person-rems for periods of 100 and 1000 years, respectively. These natural-background dose commitments could produce about 400,000 and 4,000,000 cancer deaths and about 770,000 and 7,700,000 genetic disorders, during the same time periods. From the above analysis, the staff concludes that both the dose commitments and health effects

Table C-5 Summary of 100-year environmental dose commitments per year of operation of the model 1000-MWe light-water reactor

Source	Total body (person-rems)	Total body risk equivalent (person-rems)
All nuclides in Table S-3 except radon-222 and technetium-99	550	650
Radon-222		
Mining, milling, and active tailings, 5200 Ci	140	800
Unreclaimed open-pit mines, 3700 Ci	96	550
Stabilized tailings, 100 Ci	3	15
Technetium-99, 1.3 Ci*	<1	<10
Total	790	2000

*Dose commitments are based on the "prompt" release of 1.3 Ci/RRY. Additional releases of technetium-99 are estimated to occur at a rate of 0.0039 Ci/yr/RRY after 2000 years of placing wastes in a high-level-waste repository.

of the LWR-supporting uranium fuel cycle are very small when compared with dose commitments and potential health effects to the U.S. population resulting from all natural-background sources.

6. Radioactive Wastes

The quantities of buried radioactive waste material (low-level, high-level, and transuranic wastes) associated with the uranium fuel cycle are specified in Table S-3. For low-level waste disposal at land-burial facilities, the

Commission notes in Table S-3 that there will be no significant radioactive releases to the environment. The Commission notes that high-level and transuranic wastes are to be buried at a Federal repository and that no release to the environment is associated with such disposal. NUREG-0116, which provides background and context for the high-level and transuranic waste values in Table S-3 established by the Commission, indicates that these high-level and transuranic wastes will be buried and will not be released to the biosphere. No radiological environmental impact is anticipated from such disposal.

7. Occupational Dose

The annual occupational dose attributable to all phases of the fuel cycle for the model 1000-MWe LWR is about 200 person-rems. The staff concludes that this occupational dose will have a small environmental impact.

8. Transportation

The transportation dose to workers and the public is specified in Table S-3. This dose is small in comparison with the natural-background dose.

9. Fuel Cycle

The staff's analysis of the uranium fuel cycle did not depend on the selected fuel cycle (no recycle or uranium-only recycle), because the data provided in Table S-3 include maximum recycle-option impact for each element of the fuel cycle. Thus the staff's conclusions as to acceptability of the environmental impacts of the fuel cycle are not affected by the specific fuel cycle selected.

10. References

Branagan, E., and R. Struckmeyer, testimony from "In the Matter of Pennsylvania Power & Light Company, Allegheny Electric Cooperatives, Inc. (Susquehanna Steam Electric Station, Units 1 and 2)," U.S. Nuclear Regulatory Commission, Docket Nos. 50-387 and 50-388, presented on October 14, 1981, in the transcript following page 1894.

Council on Environmental Quality, "The Seventh Annual Report of the Council on Environmental Quality," Figs. 11-27 and 11-28, pp. 238-239, September 1976.

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Killough, G. G., "A Diffusion-Type Model of the Global Carbon Cycle for the Estimation of Dose to the World Population from Releases of Carbon-14 to the Atmosphere," ORNL-5269, May 1977.

National Council on Radiation Protection and Measurements, NCRP, "Natural Background Radiation in the United States," NCRP Report No. 45, November 1975.

U.S. Environmental Protection Agency, "Environmental Standards for Uranium and Thorium Mill Tailings at Licensed Commercial Processing Sites (40 CFR 192), "Federal Register, Vol 48, No. 196, pp. 45926-45947, October 7, 1983.

U.S. Department of Energy, "Statistical Data of the Uranium Industry," GJO-100(8-78), January 1978.

U.S. Nuclear Regulatory Commission, NUREG-0002, "Final Generic Environmental Statement on the Use of Recycled Plutonium in Mixed Oxide Fuel in Light-Water-Cooled Reactors," August 1976.

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APPENDIX D

EXAMPLES OF SITE-SPECIFIC DOSE ASSESSMENT CALCULATIONS

APPENDIX D
EXAMPLES OF SITE-SPECIFIC DOSE ASSESSMENT CALCULATIONS

1. Calculational Approach

As mentioned in the main body of this report, the quantities of radioactive material that may be released annually from the Limerick facility are estimated on the basis of the description of the radwaste systems in the applicant's ER and FSAR and by using the calculational models and parameters developed by the NRC staff in NUREG-0016. These estimated effluent release values for normal operation, incuding anticipated operational occurrences, along with the applicant's site and environmental data in the ER and in subsequent answers to NRC staff questions, are used in the calculation of radiation doses and dose commitments.

The models and considerations for environmental pathways that lead to estimates of radiation doses and dose commitments to individual members of the public near the plant and of cumulative doses and dose commitments to the entire population within an 80-km (50-mile) radius of the plant as a result of plant operations are discussed in detail in Regulatory Guide (RG) 1.109, Revision 1. Use of these models with additional assumptions for environmental pathways that lead to exposure to the general population outside the 80-km radius is described in Appendix B of this statement.

The calculations performed by the NRC staff for the releases to the atmosphere and hydrosphere provide total integrated dose commitments to the entire population within 80 km of this facility based on the projected population distribution in the year 2000. The dose commitments represent the total dose that would be received over a 50-year period, following the intake of radioactivity for 1 year under the conditions existing 20 years after the station begins operation (that is, the mid-point of station operation). For younger persons, changes in organ mass and metabolic parameters with age after the initial intake of radioactivity are accounted for.

2. Dose Commitments from Radioactive Effluent Releases

The NRC staff's estimates of the expected gaseous and particulate releases (listed in Table D-1) along with the site meteorological considerations (summarized in Table D-2) were used to estimate radiation doses and dose commitments for airborne effluents. Individual receptor locations and pathway locations considered for the maximally exposed individual in these calculations are listed in Table D-3.

Annual average relative concentration (χ/Q) and relative deposition (D/Q) values at specific receptor points were calculated using the variable trajectory plume segment model described in NUREG/CR-0523. This model includes spatial and temporal variations in airflow. Releases through the turbine enclosure vent (north stack) and the reactor enclosure vent (south stack) have been considered to be partially elevated, with vent flow from both units based on the criteria contained in RG 1.111 for all transport directions except northwest through north through northeast. Because of the airflow around the cooling towers, the concentration and deposition values in these northerly directions were deemed to be represented best by the assumption that the vent releases were at ground level with mixing allowed for the turbulence in the wake of these structures. A 1-year period of record (1974) of onsite meteorological data was used in this evaluation.

Also X/Q and D/Q values for specific receptor points, representing a release duration of 400 hours, were calculated and used with radioactive releases to the environment from the mechanical vacuum pump. For this evaluation, the atmospheric dispersion model for intermittent releases, as described in NUREG/CR-2919, was utilized. This model is also consistent with the variable trajectory model described in NUREG/CR-0523. A 1-year period of record (1974) of onsite data was used as input to the model.

Annual average χ/Q and D/Q value arrays to 80 km (50 miles) for use in population dose assessment were based on the straight-line gaussian atmospheric dispersion model, described in RG 1.111, modified to reflect potential spatial and temporal variations in airflow, using the conservative correction factors in NUREG/CR-2919. Releases through the turbine enclosure and the reactor enclosure vents have been considered to be partially elevated, based on the criteria in RG 1.111 for all transport directions except north-northwest, north, and north-northeast. Because of airflow around the cooling towers, releases from these vents were assumed to be at ground level, with mixing allowed for the turbulent wake of reactor structures for the transport directions of north-northwest, north, and north-northeast. A 5-year period of record (January 1972-December 1976) of onsite meteorological data was used for this evaluation.

In these evaluations, wind speed and direction data were based on measurements at the 9.1-m level, and atmospheric stability was defined by the vertical temperature gradient measured between the 52.2-m and 7.9-m levels.

In addition, the NRC staff estimates of the expected liquid releases (listed in Table D-4), along with the site hydrological considerations (summarized in Table D-5), were used to estimate radiation doses and dose commitments from liquid releases.

(a) Radiation Dose Commitments to Individual Members of the Public

As explained in the text, calculations are made for a hypothetical individual member of the public (that is, the maximally exposed individual) who would be expected to receive the highest radiation dose from all pathways that contribute. This method tends to overestimate the doses because assumptions are made that would be difficult for a real individual to fulfill.

The estimated dose commitments to the individual who is subject to maximum exposure at selected offsite locations from airborne releases of radioiodine and particulates, and waterborne releases are listed in Tables D-6, D-7, and D-8. The maximum annual total body and skin dose to a hypothetical individual and the maximum beta and gamma air dose at the site boundary are presented in Tables D-6, D-7, and D-8.

The maximally exposed individual is assumed to consume well above average quantities of the potentially affected foods and to spend more time at potentially affected locations than the average person as indicated in Tables E-4 and E-5 of Revision 1 of RG 1.109.

(b) Cumulative Dose Commitments to the General Population

Annual radiation dose commitments from airborne and waterborne radioactive releases from the Limerick facility are estimated for two populations in the year 2000: (1) all members of the general public within 80 km (50 miles) of the station (Table D-7) and (2) the entire U.S. population (Table D-9). Dose commitments beyond 80 km are based on the assumptions discussed in Appendix B. For perspective, annual background radiation doses are given in the tables for both populations.

3. References

U.S. Nuclear Regulatory Commission, NUREG-0016, F. P. Cardile and R. R. Bellamy, eds, "Calculation of Radioactive Materials in Gaseous and Liquid Effluents from Boiling Water Reactors," Revision 1, January 1979.

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---, NUREG/CR-2919, J. F. Sagendorf, S. T. Goll, and W. F. Sandusky, "User Guide for XOQDOQ: Evaluating Routine Effluent Releases at Commercial Nuclear Power Stations," Battelle Memorial Institute, Pacific Northwest Laboratories, September 1982.

---, Regulatory Guide (RG) 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 1, October 1977.

---, RG 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water Reactors," Revision 1, 1977.

Table D-1 Calculated releases of radioactive materials in gaseous effluents from the Limerick nuclear facility (Ci/yr per reactor)

Nuclides	Turbine enclosure vent release (north stack) plus reactor enclosure vent release (south stack) (continuous)*	Turbine enclosure vent release (north stack) (intermittent, 400-hr/yr)*	Total
Ar-41	15		15
Kr-83m	a	a	a
Kr-85m	29	a	29
Kr-85	240	a	240
Kr-87	63	a	63
Kr-88	95	a	95
Kr-89	610	a	610
Xe-131m	7	a	7
Xe-133m	a	a	a
Xe-133	550	1300	1900
Xe-135m	990	a	990
Xe-135	740	500	1200
Xe-137	1300	a	1300
Xe-138	1000	a	1000
		Total Noble Gases	7400
Cr-51	0.00023	b	0.00023
Mn-54	0.00046	b	0.00046
Fe-59	0.000097	b	0.000097
Co-58	0.00011	b	0.00011
Co-60	0.0011	b	0.0011
Zn-65	0.0011	b	0.0011
Sr-89	0.000090	b	0.000090
Sr-90	0.0000033	b	0.0000033
Nb-95	0.0011	b	0.0011
Zr-95	0.00032	b	0.00032
Mo-99	0.0066	b	0.0066
Ru-103	0.00024	b	0.00024
Ag-110m	0.00000042	b	0.00000042
Sb-124	0.000022	b	0.000022
Cs-134	0.00077	b	0.00077
Cs-136	0.00011	0.0000019	0.00011
Cs-137	0.0011	b	0.0011
Ba-140	0.0023	b	0.0023
Ce-141	0.00031	b	0.00031
		Total Particulates	0.016
I-131	0.066	0.041	0.11
I-133	0.87	0.43	1.3
H-3	92	b	92
C-14	9.5	b	9.5

*Mixed mode releases for all transport directions except for the NW, NNW, N, NNE, and NE, where the releases are assumed to be ground level. See text of Appendix D, Section 1.

[a]Less than 1.0 Ci/yr for noble gases and C-14; less than 10^{-4} Ci/yr for iodine.

[b]Less than 1% of total for this nuclide.

Table D-2 Summary of atmospheric dispersion factors (χ/Q) and relative deposition values for maximum site boundary and receptor locations near the Limerick nuclear facility*

Location**	Source***	χ/Q (sec/m^3)	Relative Deposition (m^{-2})
Nearest effluent-control boundary (0.79 km NE of Units 1 and 2)	A B	1.1×10^{-5} 3.6×10^{-5}	1.7×10^{-8} 8.7×10^{-8}
Nearest residence and garden (1.0 km NE of Units 1 and 2)	A B	7.6×10^{-6} 2.6×10^{-5}	1.1×10^{-8} 6.2×10^{-8}
Nearest milk cow (4.3 km NE of Units 1 and 2)	A B	6.6×10^{-7} 2.7×10^{-6}	8.0×10^{-10} 4.2×10^{-9}
Nearest milk goat (1.8 km ESE of Units 1 and 2)	A' B'	3.2×10^{-7} 1.6×10^{-6}	2.9×10^{-9} 1.1×10^{-8}
Nearest meat animal (1.6 km NNE of Units 1 and 2)	A B	1.7×10^{-6} 7.8×10^{-6}	4.2×10^{-9} 2.0×10^{-8}

*The values presented in this table are corrected for radioactive decay and cloud depletion from deposition, where appropriate, in accordance with Regulatory Guide 1.111, Rev. 1, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light Water Reactors," July 1977.

**"Nearest" refers to that type of location where the highest radiation dose is expected to occur from all appropriate pathways.

***Sources:
- A - Reactor-building (south stack), or Turbine building (north stack), Unit 1 or 2, continuous, ground level release.
- A' - Reactor-building (south stack) or Turbine-building (north stack), Unit 1 or 2, continuous, mixed mode release.
- B - Turbine-building (north stack), Unit 1 or 2, 400 hours/yr, intermittent, ground level release.
- B' - Turbine-building (north stack), Unit 1 or 2, 400-hours/yr, intermittent, mixed mode release.

Table D-3 Nearest pathway locations used for maximally exposed individual dose commitments for the Limerick nuclear facility

Location	Sector	Distance (km)
Nearest effluent-control boundary*	NE of Units 1 and 2	0.79
Residence and garden**	NE	1.0
Milk cow	NE	4.3
Milk goat	ESE	1.8
Meat animal	NNE	1.6

*Beta and gamma air doses, total body doses, and skin doses from noble gases are determined at the effluent-control boundaries in the sector where the maximum potential value is likely to occur.

**Dose pathways including inhalation of atmospheric radioactivity, exposure to deposited radionuclides, and submersion in gaseous radioactivity are evaluated at residences. This particular location includes doses from vegetable consumption as well.

Table D-4 Calculated release of radioactive materials in liquid effluents from Limerick nuclear facility, Units 1 and 2

Nuclide	Ci/yr per reactor*	Nuclide	Ci/yr per reactor
Corrosion and Activation Products		Fission Products (cont'd)	
Na-24	0.0076	Tc-101	0.000070
P-32	0.00038	Ru-103	0.00033
Cr-51	0.016	Tc-104	0.00018
Mn-54	0.0047	Ru-105	0.00077
Mn-56	0.011	Ru-106	0.00030
Fe-55	0.011	Ag-110m	0.00060
Fe-59	0.00019	Te-129m	0.000040
Co-58	0.0095	Te-131m	0.000090
Co-60	0.016	I-131	0.0058
Cu-64	0.022	I-132	0.011
Ni-63	0.00025	I-133	0.042
Ni-65	0.00006	I-134	0.0040
Zn-65	0.00022	Cs-134	0.011
Zn-69m	0.0015	I-135	0.026
W-187	0.00026	Cs-136	0.00080
Np-239	0.0078	Cs-137	0.017
		Cs-138	0.0014
Fission Products		Ba-139	0.00090
		Ba-140	0.0013
Br-83	0.0012	Ba-141	0.000020
Br-84	0.000090		
Rb-89	0.000080	Ce-141	0.00023
Sr-89	0.00022	La-142	0.00061
Sr-90	0.000070	Ce-143	0.000030
		Pr-143	0.000040
Sr-91	0.0025	Ce-144	0.0035
Y-91	0.00021		
Sr-92	0.0023	All Others	0.0054
Y-92	0.0043		
Y-93	0.0026	Total (except H-3)	0.27
		H-3	12
Zr-95	0.0015		
Nb-95	0.0018		
Nb-98	0.00015		
Mo-99	0.0020		
Tc-99m	0.011		

*Nuclides whose release rates are less than 10^{-5} Ci/yr per reactor are not listed individually but are included in "all others."

Table D-5 Summary of hydrologic transport and dispersion for liquid releases from the Limerick nuclear facility*

Location	Transit Time (hours)**	Dilution Factor**
<u>ALARA Dose Calculations</u>		
Nearest drinking-water intake (Royersford, Pennsylvania)	1.5	85
Nearest sport-fishing location (discharge area)***	0.1	28
Nearest shoreline (bank of Schuylkill River near discharge area)	0.1	28
<u>Population Dose Calculations</u>:		
Sport fishing, shoreline usage, swimming, boating at the following segments of the Schuykill River downstream from the Limerick discharge area:		
0-16 km	4	85
16-32 km	16	87
32-48 km	27	99
48-64 km	50	110
64-80 km	50	110
Drinking Water intakes:		
Citizens Utility Home Water Company (Royersford)	1.5	85
Phoenixville Water Authority	10	85
Philadelphia Suburban Water Company	16	85
Keystone Water Company (Norristown)	27	99
City of Philadelphia	50	110

*See Regulatory Guide 1.113, "Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I," April 1977.

**With the exception of those for the plant discharge area, the transit times and the dilution factors for other locations were from ER-OL Table 5.2-8.

***Assumed for purposes of an upper limit estimate; detailed information not available.

Table D-6 Annual dose commitments to a maximally exposed individual near the Limerick nuclear station

Location	Pathway	Doses (mrems/yr per unit, except as noted)					
		Noble Gases in Gaseous Effluents					
		Total Body		Skin	Gamma Air Dose (mrads/yr/unit)	Beta Air Dose (mrads/yr/unit)	
Nearest* site boundary (0.79 km NE)	Direct radiation from plume	1.5		4.0	2.4	3.9	
		Iodine and Particulates in Gaseous Effluents**					
		Total Body		Organ			
Nearest*** site boundary (0.79 km NE)	Ground deposition	a	(T)	a	(C)	(thyroid)	
	Inhalation	a	(T)	3.0	(C)	(thyroid)	
Nearest residence and garden (1.0 km NE)	Ground deposition	a	(C)	a	(C)	(thyroid)	
	Inhalation	a	(C)	2.7	(C)	(thyroid)	
	Vegetable consumption	1.6	(C)	7.4	(C)	(bone)	
Nearest milk cow (4.3 km NE)	Ground deposition	a	(I)	a	(I)	(thyroid)	
	Inhalation	a	(I)	0.22	(I)	(thyroid)	
	Cow milk consumption	0.15	(I)	2.6	(I)	(thyroid)	
Nearest milk goat (1.8 km ESE)	Ground deposition	a	(I)	a	(I)	(thyroid)	
	Inhalation	a	(I)	0.14	(I)	(thyroid)	
	Goat milk consumption	a	(I)	7.6	(I)	(thyroid)	
Nearest meat animal (1.6 km NNE)	Meat consumption	a	(C)	0.28	(C)	(bone)	
		Liquid Effluents**					
		Total Body		Organ			
Nearest drinking water	Water ingestion	0.0055(I)		0.16(I) (thyroid)			
Nearest fish at plant-discharge area	Fish consumption	0.21(A)		0.58(C) (bone)			
Nearest shore access near plant-discharge area	Shoreline recreation	0.0073(A or T)		0.0086 (A or T) (skin)			

*"Nearest" refers to that site boundary location where the highest radiation doses as a result of gaseous effluents have been estimated occur.

**Doses are for the age group and organ that results in the highest comulative dose for the location: A-adult, T-teen, C-child, I-infant. Calculations were made for these age groups and for the following organs: gastrointestinal tract, bone, liver kidney, thyroid, lung, and skin.

***"Nearest" refers to the location where the highest radiation dose to an individual from all applicable pathways has been estimated.

[a] Less than 0.10 mrem/year

Table D-7 Calculated Appendix I dose commitments to a maximally exposed individual and to the population from operation of Limerick nuclear facility

	Annual Dose per Reactor Unit	
	Individual	
	Appendix I Design Objectives*	Calculated Doses**
Liquid effluents		
Dose to total body from all pathways	3 mrems	0.22 mrem
Dose to any organ from all pathways	10 mrems	0.59 mrem (bone)
Noble-gas effluents (at site boundary)		
Gamma dose in air	10 mrads	2.4 mrads
Beta dose in air	20 mrads	3.9 mrads
Dose to total body of an individual	5 mrems	1.5 mrem
Dose to skin of an individual	15 mrems	4.0 mrems
Radioiodines and particulates***		
Dose to any organ from all pathways	15 mrems	7.7 mrems (thyroid)
	Population Dose Within 80 km, person-rems	
	Total Body	Thyroid
Natural-background radiation†	800,000.	
Liquid effluents	0.77	2.5
Noble-gas effluents	5.3	5.3
Radioiodine and particulates	9.7	56

*Design Objectives from Sections II.A, II.B, II.C, and II.D of Appendix I, 10 CFR Part 50 consider doses to maximally exposed individual and to population per reactor unit.

**Numerical values in this column were obtained by summing appropriate values in Table D-6. Locations resulting in maximum doses are represented here.

***Carbon-14 and tritium have been added to this category.

†"Natural Radiation Exposure in the United States," U.S. Environmental Protection Agency, ORP-SID-72-1, June 1972; using the average background dose for Pennsylvania of 99 mrems/yr, and year 2000 projected population of 8,100,000 persons within 80 km radius of the Limerick facility (Table 2.1-12, Environmental Report, Operating License Stage, Limerick Generating Station, Units 1 and 2, Revision 8, December 1982, Philadelphia Electric Company).

Table D-8 Calculated RM-50-2 dose commitments to a maximally exposed individual from operation of the Limerick nuclear facility*

	Annual Dose per Site	
	RM-50-2 Design Objectives**	Calculated Doses
Liquid effluents		
Dose to total body or any organ from all pathways	5 mrems	1.2 mrems
Activity-release estimate, excluding tritium (Ci/yr)	10	0.54
Noble-gas effluents (at site boundary)		
Gamma dose in air	10 mrads	4.8 mrads
Beta dose in air	20 mrads	7.8 mrads
Dose to total body of an individual	5 mrems	3.0 mrems
Dose to skin of an individual	15 mrems	8.0 mrems
Radioiodines and particulates***		
Dose to any organ from all pathways	15 mrems	15 mrems child bone or infant thyroid
I-131 activity release (Ci/yr)	2	0.22

*An optional method of demonstrating compliance with the cost-benefit Section (II.D) of Appendix I to 10 CFR Part 50.

**Annex to Appendix I to 10 CFR Part 50.

***Carbon-14 and tritium have been added to this category.

Table D-9 Annual total-body population dose commitments, year 2000 (both units)

Category	U.S. population dose commitment, person-rems/yr
Natural background radiation*	26,000,000*
Limerick Station Units 1 and 2 (combined) operation	
Plant workers	1600.
General public	
Liquid effluents**	1.5
Gaseous effluents	75.
Transportation of fuel and waste	6.

*Using the average U.S. background dose (100 mrems/yr) and year 2000 projected U.S. population from "Population Estimates and Projections," Series II, U.S. Department of Commerce, Bureau of the Census, Series P-25, No. 704, July 1977.

**80-km (50-mile) population dose

APPENDIX E

NPDES PERMIT

As of the publication of this FES the applicant does not have an NPDES permit. The applicant informed the NRC staff by letter dated March 16, 1984 that application had been made to the Pennsylvania Department of Environmental Resources (Pa.DER) for the permit on August 15, 1983. Revisions to the application were submitted in September and in December, 1983. The Pa.DER did not predict an issuance date for the permit. The permit is necessary for operation of the plant (to permit discharges from the plant) pursuant to the Federal Clean Water Act. The U.S. Environmental Protection Agency has designated the Pa.DER as the responsible state agency for implementation of the Act's requirements at the state and local level.

APPENDIX F

HISTORIC AND ARCHEOLOGIC SITES

This appendix lists properties presently included or eligible for inclusion on the National Register of Historic Places within 15 km of the Limerick station or 2 km of the transmission line routes (ER-OL response to question 310.10).

A letter from the State Historic Preservation Officer regarding the effect of Limerick station and/or the Limerick transmission system is also included.

The properties presently listed or eligible for listing on the National Register of Historic Places within 15 km of the site or within 2 km of the transmission routes are

Coventry Hall, Coventryville, off Pennsylvania Route 23

Good News Building (Yellow Springs Spa), north of Chester Springs on Art School Road

Hall's Bridge, about 4.8 km north of Chester Springs at Sheeder Road and Birch Run

Martin-Little House, south of Phoenixville off Pennsylvania Route 113 on Church Road

Prizer's Mill Complex, west of Phoenixville on Seven Stars Road

Coventryville Historic District, south of Pottstown on Pennsylvania Route 113

Simon Meredith House, 0.8 km west of Pughtown on Pughtown Road

Townsend House, southwest of Pughtown off Pennsylvania Route 110

River Bend Farm, north of Spring City on Sanatoga Road

Kuster Mill, in the vicinity of Collegeville on Skippack Creek at Mill Road and Walter Street Road

Pottstown Roller Mill, South and Hanover Streets, Pottstown

Henry Antes House, northeast of Pottstown on Colonial Road

Pottsgrove Mansion, west of Pottstown on Benjamin Franklin Highway

John Englehardt Homestead, west of Schwenksville off Pennsylvania Route 73 on Keyser Road

Nathan Michener House, west of Bucktown on Ridge Road

Birchrunville General Store, Hollow and Flowing Springs Roads, Birchrunville

Kimberton Village Historic District, Kimberton, both sides of Hares Hill Road between Kimberton and Cold Stream Road

Kennedy Bridge, north of Kimberton off Pennsylvania Route 23 on Seven Stars Road over French Creek

Rapps Bridge, in the vicinity of Mont Clare off Pennsylvania Route 724 on Mowere Road

Charlestown Village Historic District, southwest of Phoenixville on Charlestown Road

Deery Family Homestead, west of Phoenixville

Fagley House, west of Phoenixville on Art School Road

Hare's Hill Road Bridge, west of Phoenixville on Hare's Hill Road

George Hartman House, west of Phoenixville on Church Road

Conrad Grubb Homestead, northwest of Schwenksville on Perkiomenville Road

Long Meadow Farm (Plank House and Barn), northwest of Schwenksville on Pennsylvania Route 73

Pennypacker Mansion, 5 Haldeman Road, in the Schwenksville vicinity

Sunrise Mill, 4.8 km west of Schwenksville on Neiffer Road

Augustus Lutheran Church, 7th Avenue E and Main Street, Trappe

Old Swede's House, Old Philadelphia Pike, Douglasville

Gabriel's Episcopal Church, U.S. Route 422, Douglasville

White Horse Tavern, 509 Old Philadelphia Pike, Douglasville

Washington's Headquarters, Valley Creek Road near the junction of Pennsylvania Routes 252 and 23

Warren Z. Cole House (Kidder-DeHaven House), Skippack Pike and Evansburg Road

Peter Wentz Homestead, Schultz Road, Worcester

COMMONWEALTH OF PENNSYLVANIA
PENNSYLVANIA HISTORICAL AND MUSEUM COMMISSION
WILLIAM PENN MEMORIAL MUSEUM AND ARCHIVES BUILDING
BOX 1026
HARRISBURG, PENNSYLVANIA 17120

October 5, 1983

A. Schwencer, Chief
Licensing Branch No. 2
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Re: Limerick Generating Station
File No. ER 82-042M-0047

Dear Mr. Schwencer:

This is in response to your letter requesting our opinion on the effect on historic and archeological resources of the Nuclear Regulatory Commission granting an operating permit for Limerick Generating Station. As stated in previous correspondence (letters dated April 1, 1983 and December 8, 1982) we believe the construction of transmission lines associated with the station will have no adverse effect if archeological investigations and data recovery are carried out and if mitigating measures to reduce or eliminate negative visual impacts on several historic sites are taken. Outside of these concerns which have not yet been formally addressed, we believe operations of the station will have no effect on significant historic or archeological resources.

Please let me know if you have any additional questions.

Sincerely,

Donna Williams, Chief
Division of Planning & Protection
Bureau for Historic Preservation
(717) 783-8947

cc: Brian Richter, NRC ✓

DW:jk

APPENDIX G

PARTIAL INITIAL DECISION
(ON SUPPLEMENTARY COOLING WATER SYSTEM CONTENTIONS)

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

BEFORE ADMINISTRATIVE JUDGES:

Lawrence Brenner, Chairman
Dr. Richard F. Cole
Dr. Peter A. Morris

In the Matter of	ASLBP Docket No. 81-465-07 OL
PHILADELPHIA ELECTRIC COMPANY	(NRC Docket Nos. 50-352-OL 50-353-OL
(Limerick Generating Station, Units 1 and 2)	March 8, 1983

COURTESY NOTIFICATION

As circumstances warrant from time to time, the Board will mail copies of its Partial Initial Decisions directly to each party, petitioner or other interested participant. This is intended solely as a courtesy and convenience to those served to provide extra time. Official service will be separate from the courtesy notification and will continue to be made by the Office of the Secretary of the Commission. Unless otherwise stated, time periods will be computed from the official service.

I hereby certify that I have today mailed copies of the Board's Partial Initial Decision (On Supplementary Cooling Water System Contentions) to the persons designated on the attached Courtesy Notification List.

Valarie M. Lane
Secretary to Judge Brenner
Atomic Safety and Licensing
Board Panel

Bethesda, Maryland

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U.S. Nuclear Regulatory Commission
Washington, DC 20555

SERVED MAR 08 1983

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

BEFORE ADMINISTRATIVE JUDGES:

Lawrence Brenner, Chairman
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PHILADELPHIA ELECTRIC COMPANY	(NRC Docket Nos. 50-352-OL 50-353-OL)
(Limerick Generating Station, Units 1 and 2)	March 8, 1983

PARTIAL INITIAL DECISION
(ON SUPPLEMENTARY COOLING WATER SYSTEM CONTENTIONS)

Appearances

Troy B. Conner, Jr., Esq., Mark J. Wetterhahn, Esq., Robert M. Rader, Esq., and Ingrid M. Olson, Esq., of Conner & Wetterhahn, P.C., Washington, D.C., for Philadelphia Electric Company.

Joseph Rutberg, Esq., Ann P. Hodgdon, Esq., and Elaine I. Chan, Esq., Office of the Executive Legal Director, U.S. Nuclear Regulatory Commission, Washington, D.C., for the Nuclear Regulatory Commission Staff.

Robert J. Sugarman, Esq., of Sugarman and Denworth, Philadelphia, Pennsylvania, for Del-Aware Unlimited, Inc.

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UNITED STATES OF AMERICA
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(Limerick Generating Station, Units 1 and 2)	March 8, 1983

PARTIAL INITIAL DECISION (ON SUPPLEMENTARY COOLING WATER SYSTEM CONTENTIONS)

I. OPINION

A. Summary of Conclusions

On the basis of the record before it, the Board finds contrary to the contention of the intervenor, that there would be no significant adverse impact on the populations of American shad and shortnose sturgeon in the Delaware River as a result of operation of the presently proposed Point Pleasant intake. The Board also finds that there is no evidence that the proposed intake would have an adverse impact on recreational activities in the Delaware River.

The Board finds that noise from operation of intake as it is presently proposed could have a significantly adverse impact on the Point Pleasant proposed historic district. The Board, in its order, is imposing a condition which requires that a determination be made, if the intake is built, as to whether there are such significant noise impacts and, if so, requires that such impact be minimized. The Board concludes that after any necessary noise mitigation measures have been undertaken, operation of and maintenance for the proposed intake and pumping station would not have a significantly adverse effect on the proposed historic district.

B. Background

On March 17, 1981, the Philadelphia Electric Company (PECo or the Applicant) filed with the Nuclear Regulatory Commission (NRC or Commission) an application for licenses to operate Units 1 and 2 of its Limerick Generating Station. The application was docketed by the NRC on July 27, 1981.

The facility for which the licenses are sought is located in Limerick Township of Montgomery County, Pennsylvania. It is on the east bank of the Schuylkill River, approximately four miles downriver from Pottstown. Licenses are sought to operate two boiling water nuclear reactors, each with a rated core power level of 3,293 megawatts thermal and a net electrical output of 1,055 megawatts electric. Final Safety Analysis Report (FSAR) at 1.1-1.

On August 21, 1981, the Commission published in the Federal Register a notice of "Receipt of Application for Facility Operating Licenses; Consideration of Issuance of Facility Operating Licenses; Availability of Applicant's Environmental Report; and Opportunity for Hearing." 46 Fed. Reg. 42557 (1981). On September 14, 1981, this Atomic Safety and Licensing Board (Licensing Board or Board) was established to preside in this proceeding. 46 Fed. Reg. 45715 (1981).

Requests for a hearing and petitions to intervene were received from thirteen individuals and groups. A special prehearing conference was held on January 6-8, 1982 to consider these petitions and requests. On June 1, 1982, the Board issued a Special Prehearing Conference Order (SPCO) which admitted some of the petitioners as intervenors and admitted some of their proposed contentions for litigation. LBP-82-43A, 15 NRC 1423 (1982).

Del-Aware Unlimited, Inc. (Del-Aware) was among the groups admitted as intervenors. Four of Del-Aware's proposed contentions were admitted. The Board subsequently reconsidered and denied admission of one of these contentions. Memorandum and Order, slip op. at 5 (July 14, 1982). Three additional contentions were proposed by Del-Aware in September, 1982, and were denied admission by this Board. Memorandum and Order (January 24, 1983). Petitions to reconsider this denial and to file a late contention were filed by Del-Aware in February, 1983. These petitions are denied in a separate order being issued today.

Del-Aware's three admitted contentions concern environmental impacts from operation of a supplementary cooling water system which would furnish water to Limerick from the Delaware River and would also provide water to the Neshaminy Water Resources Authority (NWRA) for municipal use. (Finding 4). The supplementary cooling water system requires construction of an intake and a pumping station at Point Pleasant, Pennsylvania. Water will be carried from Point Pleasant through a transmission main to the proposed Bradshaw Reservoir. From the Bradshaw Reservoir, some of the water will be pumped into another transmission main and carried to the East Branch of the Perkiomen Creek.[1] After flowing for some distance in the Perkiomen Creek, this portion of the water will be pumped into a third transmission main which will carry it to the Limerick plant site, some thirty miles from Point Pleasant. See, SPCO, LBP-82-43A, 15 NRC at 1462-63.

Del-Aware's three admitted contentions allege that there will be significant impacts from operation of this system which were not anticipated at the time the construction permits were authorized, since they are attributable to changes in the proposed system since that time. The Board determined that, because the system had not yet been constructed and because mitigation of operational impacts can often best be achieved by design and location decisions made before construction,

1 Water for use by the NWRA will be carried from the Bradshaw Reservoir by a different route.

it would make every effort to reach a decision on these contentions before the supplementary cooling water system was constructed. See SPCO, LBP-82-43A, 15 NRC at 1479-80; Memorandum and Order, slip op. at 3-4, 15-18 (July 14, 1982); Confirmatory Memorandum and Order (October 20, 1982). To that end, twelve days of hearing were held on these three contentions October 4-8, 18-22, and 25-26, 1982.

One of the contentions which was the subject of this hearing concerned the allegedly adverse effect a changed intake location would have on American shad, shortnose sturgeon and recreation. (Finding 6). Another contention concerned the impact of noise from operation of the intake pump station and the impact of dredging maintenance of the intake on the Point Pleasant proposed historic district (Finding 133). A third contention, concerning impacts of the Bradshaw Reservoir, was withdrawn by Del-Aware pursuant to a stipulation reached among Del-Aware, the Applicant, and the NRC Staff (Staff). (Finding 5).

C. Scope of Decision

The Board's role in considering impacts of the supplementary cooling water system is complicated by the fact that several other federal agencies and parts of the NRC have a role in reviewing this water diversion. These reviews have, in general, been ongoing as this hearing has progressed. We have previously discussed at some length the effect that the conclusions reached as part of these other reviews, particularly those reached by the DRBC, should have on our decision-making. See SPCO, supra, 15 NRC at 1423, 1458-70 ; Memorandum and Order Concerning Objections to the [SPCO], slip op. at 9-10 (July 14, 1982); Memorandum and Order (Denying Del-Aware's Request for Reconsideration of DRBC Preclusion on Water Allocation Issues), LBP-82-72, 16 NRC ___ (September 3, 1982).

Since the hearing on these issues was completed, the Army Corps of Engineers has issued a "dredge and fill" permit to the NWRA, pursuant to Section 404 of the Clean Water Act 33, U.S.C. § 1344 (1976 & Supp). The Applicant and the Staff have argued in their proposed findings that we are consequently confronted with a preclusion, pursuant to Section 511 (c)(2) of the Clean Water Act, on the matters considered by the Corps in issuing its permits. Section 511(c)(2) states:

> (2) Nothing in the National Environmental Policy Act of 1969 (83 Stat. 852) shall be deemed to --
>
> (A) authorize any Federal agency authorized to license or permit the conduct of any activity which may result in the discharge of a pollutant into the navigable waters to review any effluent limitation or other requirement established pursuant to this Act or the adequacy of any certification under section 401 of this Act; or
>
> (B) authorize any such agency to impose, as a condition precedent to the issuance of any license or permit, any effluent limitation other than any such limitation established pursuant to this Act.

33 U.S.C. § 1371 (1976 & Supp.)

Having conducted a full evidentiary hearing on these matters and considered them in greater detail than it appears to us that the Corps has, we would set forth our findings even if we concluded that the preclusion prevented us from ordering action we believed desirable. Because we have concluded, based on the merits of the record before us, that there will be no significant impact on the river from operation of the intake, we need not reach the question of whether § 511 (c)(2) would have barred us from ordering mitigation measures relative to such impacts.

We note, however, that one of the contentions which was the subject of this hearing concerned noise impacts on the surrounding environment. Actions we are ordering relating to this contention are not barred by the Clean Water Act preclusion. This Commission has consistently interpreted § 511 (c)(2) to apply only to aquatic impacts. See Public Service Co. of New Hampshire (Seabrook Station, Units 1 and 2), CLI-78-1, 7 NRC 1, 25, 26, 27, aff'd sub nom. New England Coalition on Nuclear Pollution v. NRC, 582 F.2d 87 (1st Cir. 1978); Tennessee Valley Authority (Yellow Creek Nuclear Plant, Units 1 and 2), ALAB-515, 8 NRC 702, 715 (1978). Indeed, this is the logical scope of the preclusion when one considers that the objective of the act from which the preclusion comes is "to restore, and maintain the chemical, physical, and biological integrity of the Nation's waters." Clean Water Act § 101, 33 U.S.C. § 1252.

In addition, the Staff argues that because the Final Environmental Statement (FES) on the operation of Limerick has not been issued and the overall cost/benefit analysis has not been done, we may not impose conditions in this order which require mitigation of particular impacts. We disagree. Although the overall cost/benefit balance for a plant may be favorable, the National Environmental Policy Act (NEPA), 42 U.S.C. §§ 4332 et seq. (1976), authorizes the Commission, and Licensing Boards in particular, to impose license conditions to minimize particular impacts. Detroit Edison Co. v. NRC, 630 F.2d 450 (6th Cir. 1980); Kansas Gas and Electric Co. (Wolf Creek Nuclear Generating Station, Unit No. 1), CLI-77-1, 5 NRC 1, 8-9 (1977); Public Service Co. of New Hampshire (Seabrook Station, Units 1 and 2), ALAB-422, 6 NRC 33, 82-84 (1977), aff'd. sub nom. Public Service Co. v. NRC, 582 F.2d 77 (1st Cir. 1978); Detroit Edison Co. (Greenwood Energy Center, Units 2 and 3), ALAB-247, 8 AEC 936, 944-45 (1974). Accordingly, we can order actions to minimize the particular impacts we have considered without awaiting the ultimate outcome of the cost/benefit balance.

Having thoroughly considered these particular impacts, however, we will not readdress them once the FES is issued. Our conclusions on the impacts contained in this Partial Initial Decision may be incorporated into the FES and may be considered in the cost/benefit balance. The fact that these issues will be covered in the FES will not, however, mean they can be relitigated in the context of that document. It would be senseless to repeat the full hearing on these issues. Indeed, res judicata should prevent any party from once again litigating them.

D. The Proposed Intake

In July 1980, PECo and the NWRA changed their plans for the intake in the Delaware River which was to be a part of the proposed Point Pleasant diversion. Prior to 1980, the proposal had been to utilize a shoreline location in Point Pleasant and an intake with a vertical traveling screen. The new plans called for the intake to be located approximately 200 feet into the river from the Pennsylvania shore, off Point Pleasant, and to use a passive wedge-wire screen. In January 1982, it was decided to put the intake an additional 45 feet into the river along essentially the same alignment as had been proposed in July 1980. (Findings 7, 8, 10).

This last location is the one that is presently proposed. It would place the intake at river mile 157.2. This would be about 800 feet downriver of the confluence of the Delaware River and the Tohickon Creek. The intake would be about a mile and a half upstream from the Lumberville wing dam, in the pool formed by that dam. (Finding 9).

The proposed design for the intake calls for two rows of cylindrical screen sections, parallel and seven feet apart. Each row would consist of six 44-inch-diameter cylinders placed end to end. The cylinders would each have two 40-inch screen sections separated by a 44-inch solid section. The ends of each row would have protective conical end pieces. (Finding 10). Water would be able to flow into the screens around their total circumference, with the through-slot velocity remaining nearly uniform over the entire screen. (Finding 13).

The screens themselves would be made of wedge-wire wound helically around supports located at approximately six-inch intervals. The screen openings would be slots 2 mm in width. (Finding 11). This type of screen utilizes state-of-the-art technology and is superior to the vertical traveling screen which was originally planned. (Finding 12).

The bottom of the intake screens would be two feet above the river bottom. The intake would extend upwards about four feet from that point. However, even at the comparatively low flow of 3000 cubic feet per second (cfs), the top of the intake would be approximately four feet under the water surface. (Finding 15).

The river bottom below the intake screen would be covered with rip-rap. In placing the rip-rap the Applicant and NWRA would restore the contours of the river bottom to approximately what they are presently (before the intake is constructed). (Finding 18).

The maximum withdrawal by the intake would be 95 million gallons per day (MGD), which is the equivalent of 147 cfs. This would constitute 4.9% of the flow by Point Pleasant at a river flow of 3000 cfs. At the lowest anticipated flow of 2500 cfs, it would be 5.9% of the flow. Therefore, while at the lowest flows ever recorded, 95 MGD would constitute more than 10% of the water in the river at that point, it is unlikely to ever actually take that large a percentage of the river flow. (Findings 17, 71).

There would be a negligible drop in the water level of the river at the intake site as a result of the intake. At a comparatively low flow of 3000 cfs, the change in water level would be less than an inch. (Finding 16).

E. Impact Of The Intake On Shortnose Sturgeon And American Shad

Del-Aware alleged that the proposed intake would have a serious impact on two fish species, American shad and shortnose sturgeon. In an effort to demonstrate this impact, Del-Aware presented evidence not only as to the characteristics and possible presence of those species, but also to show why the intake in its proposed location would be particularly likely to affect them.

Del-Aware sought to show that the intake would be located in an eddy. An eddy is a current of water which runs contrary to the main flow in the river and may actually move circularly. Del-Aware contended that if the intake were located where it would draw water from an eddy, juvenile fish, which might tend to congregate in the eddy, would be more seriously impacted than they would be if the intake drew water from the main flow of the river. In addition, Del-Aware argued that the circular flow of an eddy would cause fish eggs and larvae, which would be at the mercy of the current, to be exposed to the intake repeatedly and would increase the risk that they would be harmed. (Findings 19, 24).

At flows below 5000 to 6000 cfs there is an eddy adjacent to the Pennsylvania shore of the Delaware River at Point Pleasant. The eddy forms as a result of a rocky bar immediately downstream of the mouth of the Tohickon Creek. This bar plays a major role in determining the size of the eddy. As water flows increase over the bar, the eddy recedes towards the Pennsylvania shore and may cease to exist. The eddy's size is at its maximum when flows are below 3000 to 4000 cfs and no water flows over the rocky bar. Even at this time, however, the intake would be located approximately 85 to 90 feet further out into the river than the far edge of the eddy. Therefore, the eddy should not increase the impact the intake would have on fish. (Findings 20, 21, 22, 23, 25).

Del-Aware also sought to show that the Applicant had not accurately presented the velocity[2] at which water would be drawn to and through the intake screens. The Applicant's evidence showed that the maximum velocity through the intake screens would be 0.5 feet per second (fps) and the average velocity would be 0.35 fps. The velocity toward the intake screen would decrease dramatically at very small distances from the screen. For example, at one foot from the screen surface, the

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2 Technically, velocity is a measure of both speed and direction. During the hearing and in this decision, "velocity" has been used interchangeably with "speed".

average velocity toward the screen would be only 0.071 fps. (Findings 26, 27).

Del-Aware's witnesses alleged that the screen could become clogged, either through biofouling or fishing hooks, and this would cause higher intake velocities. (Finding 28). It is true that clogging would cause higher intake velocities. As a Del-Aware witness testified, however, wedge-wire screen intakes are less susceptible to clogging than are most intakes. The fact that this intake would be some distance into the river and completely below the surface would further reduce the likelihood that it would become clogged. The intake is equipped with an air backflush system which should prevent or minimize the build up of potentially clogging material. Other material could be removed by a diver. (Finding 14, 29). It, therefore, seems unlikely that significant clogging of the intake screens would occur. The Applicant's intake velocity figures should be realistic.

Bypass velocity is the velocity of the river water flowing past the screens parallel to the long axis of the intake. There was some testimony that a high ratio of bypass velocity to intake velocity helps to protect aquatic life from impingement and entrainment. Some witnesses advocated a minimum velocity ratio of 2 to 1; others indicated that the 2 to 1 ratio was not important and that with a 1 to 1 ratio, or even in the absence of any bypass velocity, wedge-wire screen intakes are effective in protecting aquatic life. (Findings 30, 31, 32, 33).

The type of fish for which protection is sought is a factor in determining the significance of the velocity ratio. Witnesses concluded, and, based upon the extensive testimony which was presented on the characteristics of American shad and shortnose sturgeon, we agree, that the velocity ratio would not be a significant factor in protecting these species. (Finding 34).

In spite of the evidence that a 2 to 1 ratio of bypass velocity to intake velocity is not a significant factor in protecting these fish, the Applicant sought to show that a 2 to 1 ratio would, in fact, be achieved, even at flows as low as 2500 cfs. Del-Aware conducted extensive cross-examination and presented some evidence to show that the Applicant's measurements of bypass velocity were in error.

Del-Aware succeeded in demonstrating that the Applicant's data on river flows, flow distributions and river stages at the intake site were less definitive than would be desirable. The Board, in consideration of the relevance of all of the factors affecting the resolution of this matter, has no hesitancy in reaching its ultimate conclusions. However, the Board's task would have been facilitated considerably and the hearing undoubtedly would have been simplified if the Applicant's data had been more certain. This is the first stage of a proceeding in which there are likely to be hearings on many contested issues. The Board hopes that in future hearings the Applicant, as the party with the burden of proof, will present more definitive data and these problems can be avoided.

The Applicant made velocity measurements in the river at Point Pleasant on November 7, 1980, when the river flow was approximately 3000 cfs and the water surface elevation was about 70.8 feet. The measurements indicated that the velocity ratio was approximately 2 to 1 for an intake velocity of 0.5 fps. (Finding 35).

A Del-Aware witness criticized the velocity measurements because they did not include an indication of the direction of the flow. (Finding 38). It is true that maximum velocities were recorded and that flow direction was not indicated. However, the maximum amount that the flow could have varied from parallel to the long axis of the intake would have been about 25 degrees and angling toward the Pennsylvania shore. A velocity measurement taken in this direction could be converted to bypass velocity by multiplying it by the cosine of the insection angle. For a 25 degree angle the cosine would be 0.906. Hence, the bypass velocity would have been over 90 percent of what was measured even if the flow were at a 25 degree angle to the intake. (Findings 37, 39, 40, 41, 46).

Del-Aware also questioned the distances into the river at which the Applicant indicated that velocity measurements were made. The Staff made three checks on the Applicant's data and, as a result of those checks concluded that the distance measurements were probably accurate. (Findings 42, 43, 44, 45, 47). The Staff's witness acknowledged that an error of up to 25 feet could have escaped detection by these checks. For any error to be that large and escape detection, it would have to have been such that the measurements were actually made further out in the river than the Applicant's data indicate. There is no real evidence that such an error occurred. Even if it did, however, the velocity at the intake would be about 75 percent of the velocity measured a hypothetical 25 feet further out. Thus, at the 7-foot depth the velocity would be over 0.80 fps, more than twice the average intake velocity and considerably more than the maximum intake velocity. (Findings 26, 48, 49).

The Applicant also made velocity measurements on July 23, 1981, when the flow was estimated at 4500 cfs. At this time velocities past the intake were measured at over 2 fps. (Finding 36). The Staff's witness on hydrology criticized this data. His concern, however, appeared to relate to only one velocity measurement which he believed was unrealistic because it was too low. (Finding 50). This single inaccuracy could easily result from a mistake in recording the data and does not strike us as a reason to totally discount the data. In any case, the July 1981 measurements are less important than the November 1980 ones, since those from November 1980 more nearly represent velocities at the low flows which have caused concern in this proceeding.

Del-Aware also questioned the method used by the Applicant to determine the flow passing Point Pleasant. The Applicant calculated that the drainage area tributary to the river at Point Pleasant is 97 percent of the drainage area tributary to the river at Trenton, where the nearest downstream gaging station is located. (Finding 51). Therefore, the flow at Point Pleasant would average approximately 97 percent of that measured at Trenton.

Using this percentage and flow measurements at Trenton, the Applicant developed a rating curve which purported to show the relationship between water surface elevation and river flow at Point Pleasant. (Finding 52). Del-Aware was critical of the rating curve, arguing that it failed to reflect hydraulic control exercised by the Lumberville wing dam. (Finding 53).

The wing dam is located approximately 1.5 miles downstream of Point Pleasant. It has a slot approximately 100 feet wide. The slot has a minimum elevation of 64.5 feet. The wings, on each side of the slot, have an elevation of 70.7 feet. Del-Aware alleges that at different elevations different segments of the dam provide hydraulic control. Del-Aware argues that the Applicant's rating curve is inaccurate at flows under 3500 cfs because it fails to reflect the changing hydraulic control below that point. (Findings 54, 55). To illustrate this, a Del-Aware witness took the data points used to construct the Applicant's rating curve and drew two essentially parallel lines through them. One of these lines went through the points above the 71.5-foot elevation; the other went through the points below the 71.5-foot elevation and was shifted over approximately 600 or 700 cfs from the first line. (Finding 56).

The part of the rating curve which is of concern is the part which reflects low flows. Del-Aware itself has indicated that the rating curve would essentially be a straight line at river elevations below 71.5 feet. (Finding 56). Applicant confirmed the accuracy of that portion of the rating curve through use of measurements at Point Pleasant on September 12, 1981, when the flow was 3640 cfs and the river elevation was 71.27 feet. (Finding 60). Therefore, although the Lumberville wing dam may act as a hydraulic control for flows in the Point Pleasant area, this fact does not render the rating curve inaccurate at low flows.

Del-Aware was also critical of the manner in which flows in the Delaware and Raritan Canal were treated in developing the rating curve. The maximum diversion from the Delaware River through that canal is 150 cfs. (Findings 57, 58). This is a small amount of water compared to the total flow in the Delaware. A discrepancy of this entire amount would probably be a smaller error than one would accept in terms of determining flow. Therefore, it would not have a significantly detrimental effect on the accuracy of the rating curve.

In determining that the Applicant's rating curve is probably reasonably accurate, the Board has also considered certain other factors. As a Del-Aware witness testified, the Applicant used common techniques in developing the rating curve. (Finding 59).

In addition, the Board has kept in mind the use to which the rating curve has been put, that is determination of river flow on the days when velocity measurements were made. (Finding 52). While there was some doubt about the accuracy of the determination of the 4500 cfs flow on July 23, 1981 (Findings 61, 63), the 3000 cfs flow for November 7, 1980 was believed by both the Staff and the Applicant, after performing checks on the value, to be within 100 cfs of the actual flow on that date. In fact, a Del-Aware witness indicated that, if anything, the 3000 cfs figure overstated the flow. (Finding 62).

Since the 3000 cfs flow is the one measured in the low flow range, it is more important that bypass velocities at that flow be substantial. If, in fact, the flow was even less than 3000 cfs and the bypass velocities still appeared substantial, that would indicate that there would be beneficial bypass velocities at even lower flows.

After considering Del-Aware's arguments concerning the Applicant's measurements of velocities and flows, the Board concludes that, at least insofar as the measurements made on November 7, 1980 are concerned, the Applicant's data are reasonably accurate and show that the river would flow by the intake with substantial bypass velocities at flows around 3000 cfs. The Board is also convinced that the data from November 7, 1980 are sufficiently accurate that they can be used to calculate approximate bypass velocities which would be expected at even lower flows.

Velocities at 3000 cfs may be used to calculate velocities at lower flows if the distribution of velocities across the river at 3000 cfs is known and if one may reasonably assume that the velocity distribution across the river will be similar at the lower flow. (Finding 64). The Applicant's data from November 7, 1980 provide reasonable definition of the velocity distribution across the river at that flow. (Finding 65).

The velocity profile at 2500 cfs should be sufficiently similar to that at 3000 cfs to allow the bypass velocity at 2500 cfs to be calculated with reasonable accuracy. Even at 3000 cfs, the river flow is low and would be concentrated in the main channel. The flow at 2500 cfs would also primarily be in the main channel. Thus, the cross-sectional area of the water flowing in the river would not be significantly different at 2500 cfs than at 3000 cfs. (The Lumberville wing dam, if it does provide hydraulic control, would not provide a different control at 2500 cfs than at 3000 cfs. Even Del-Aware agreed that the control would be provided by the same part of the dam at flows of 3000 cfs or less. See Finding 55.) Since, if the cross-sectional area remains essentially the same, flow and river velocity will vary proportionally, the similar cross-sectional areas at 2500 cfs and 3000 cfs mean that the velocity distribution should be similar at flows of 2500 cfs and 3000 cfs. The ratio of average cross-sectional velocity to screen bypass velocity would be the same at the two flows. The bypass velocity at a flow of 2500 cfs can be calculated utilizing this ratio.

The Applicant and the Staff used the velocity measurements from November 7, 1980 to calculate what the bypass velocity of the river by the intake screens would be at 2500 cfs and concluded that the bypass velocity would be 0.8 fps. (Finding 66). Thus, even at 2500 cfs, the ratio of bypass velocity to the average intake velocity would be greater than 2 to 1 and the bypass velocity would be significantly higher than the maximum intake velocity (although not twice as high). Had we concluded that the ratio of bypass to intake velocity would be a significant factor in providing protection from the proposed intake, the calculated bypass velocity of 0.8 fps at 2500 cfs convinces us that the ratio would be adequate even at low flows.

We recognize that the bypass velocity at 2500 cfs could be somewhat lower than that calculated by the Applicant if the velocity measurement at 3000 cfs actually fails to reflect the flow passing the intake at an angle or any inaccuracy in horizontal measurements. However, even adjusting for these possible inaccuracies in the velocity measurements at 3000 cfs, we conclude the bypass velocity at 2500 cfs as calculated by this method would be close to the Applicant's 0.8 fps figure and would also provide an acceptable bypass to intake velocity ratio, even directly at the screens. Moreover, as noted, there is an extremely rapid decrease in intake velocity at very small distances from the screens. (Finding 27). Accordingly, at a distance of one foot from the screen, the ratio of bypass velocity (0.8 fps) to average intake velocity (0.071 fps) is very high -- over 11 to 1.

If there were a problem in maintaining an adequate ratio of bypass velocity to intake velocity, it would occur only at low flows since it is at low flows that the river velocity drops. The relative infrequency of low flows, particularly at those times of the year when vulnerable developmental stages of American shad and shortnose sturgeon could be present, further convinces us that there would not be a problem with maintaining an adequate velocity ratio.

Between 1913 and 1980, flows at Trenton have exceeded 2900 cfs 90 percent of the time. During that period, several storage projects and reservoirs have been built which should decrease the frequency of low flows. (Finding 67).

The lowest flow which the DRBC, the agency charged with allocating water in the Delaware River valley, anticipates will occur at Trenton in the future is 2500 cfs. (Finding 71). It is unlikely, however, that a flow this low would occur in April, May or June when shad and sturgeon eggs and larvae could be present. Historical data indicate that flows below 3000 cfs have rarely occurred during these months. In fact, in the past 20 years, such flows have occurred only about 1 percent of the time. (Findings 68, 69).

Juvenile shad and sturgeon could be present in the Point Pleasant area in July, and the historical record indicates that flows have been less than 3000 cfs a larger proportion of the time in July as compared with April through June. (Finding 70). Even during July, however, flows will be above 3000 cfs most of the time. Moreover, juvenile fish would be less dependent on the bypass velocity to assist them by the intake than eggs and larvae would be since juveniles are more mobile. Hence, low flows and a low bypass to intake velocity measurement would be of less concern at this time of year.

Because of a condition imposed by the DRBC which does not permit PECo to withdraw water from the Delaware River for use in cooling Limerick when flows at Trenton are under 3000 cfs unless PECo provides offstream storage from which it releases an amount of water equal to that it withdraws (Finding 72), the intake might never operate at flows below 3000 cfs. Even if PECo provides the offsite storage and withdraws water when flows at Trenton are less than 3000 cfs, this should be an infrequent occurrence. (Finding 67). Even at such times, the bypass velocity will be substantially higher than the intake velocity, probably more than twice the average intake velocity. (Finding 66. See also Opinion at p. 20-21). This should be more than adequate to protect shad and sturgeon.

Del-Aware also questioned whether the orientation of the intake screens relative to the river flow would be optimal for protecting the fish species in question. The slots of the screens at Point Pleasant would be roughly perpendicular to the flow; i.e., the length of the cylinders would be roughly parallel to the flow. (Finding 74). Based on the evidence presented, we conclude that the orientation of the screen slots is not an important factor contributing to the protection of fish. (Finding 73). Thus, we see no reason to consider other possible screen slot orientations.

In addition to the protective characteristics of the proposed intake, the characteristics of the two species of fish with which this hearing was concerned convince us that the intake would not have an adverse impact on these species. At all life stages of both species, the intake should have a minimal impact on the fish populations in the Delaware River.

One of the species in question is the shortnose sturgeon. The shortnose sturgeon is listed as an endangered species pursuant to the Endangered Species Act, as amended, 16 U.S.C. §§ 1531-43 (1976 & Supp). In compliance with that Act, the National Marine Fisheries Service prepared a Biological Opinion which evaluated the impact of the proposed pumping station on shortnose sturgeon. This Opinion concluded that, in compliance with the Act, the intake "is not likely to jeopardize the continued existence" of shortnose sturgeon in the Delaware River. See 16 U.S.C. § 1536 (a)(2). (Finding 75).

Although shortnose sturgeon occur in the Delaware River, there is no hard evidence that they occur at or upstream of Point Pleasant. Sampling for fish over a number of years in the stretch of the river in which the intake would be located has not found shortnose sturgeon. Nor did a study conducted between November 1981 and March 1982 which was designed specifically to sample for sturgeon in the vicinity of the proposed intake site. (Findings 76, 78, 79).

The 1981 to 1982 study used techniques appropriate for sampling for sturgeon although it was somewhat limited in terms of the number of samples taken. The study did not cover the entire period during which shortnose sturgeon could be migrating upriver to spawn. It did, however, include some sampling in late March, the time when the upriver migration begins. (Findings 79, 80).

The closest to Point Pleasant that shortnose sturgeon have actually been found is Lambertville, New Jersey. This is eight miles downstream from Point Pleasant. (Finding 77).

Sturgeon spawn over rubble, cobble or gravel bottoms in high velocity fresh water in or above the tidal reaches of the river. Spawning takes place in the main river channel near the river bottom. (Finding 82). In the Delaware River, sturgeon probably spawn in fresh water just below the Trenton fall line or in nontidal water immediately above those falls. (Finding 83). Although Point Pleasant is some distance upstream from Trenton, it does have a river bottom of the type over which sturgeon might spawn. (Finding 84).

Based on the lack of evidence of sturgeon at Point Pleasant despite sampling programs, the Board believes that it is unlikely that shortnose sturgeon spawn near Point Pleasant. On the other hand, sturgeon are difficult to sample for (Finding 80) and there has been no study at Point Pleasant specifically aimed at determining whether sturgeon spawn there. However, the Board concludes, for reasons explained below, that, even if sturgeon were to spawn near Point Pleasant, the intake would not have a substantial impact on the species.

Adult sturgeon, coming upriver to spawn should not, if healthy, be impacted by the proposed intake at all. Their size, swimming ability, and preference for the river bottom should ensure they would not be impinged or entrained. (Finding 81).

An adult female sturgeon lays approximately 140,000 eggs. The eggs are 3.0 to 3.2 mm in diameter. The eggs are dense and sink rapidly to the bottom, where they become affixed to the substrate on which they land. (Findings 82, 85).

The eggs, if present, would not be entrained or impinged by the intake in significant numbers. Because they sink rapidly, they would risk exposure to the intake for only the very short time it would take for them to sink from their spawning point near the river bottom to a depth not more than two feet off the river bottom. At that point, they would be below the intake screens and could not be affected. The few eggs that might be drawn to the intake during the short period required for them to sink would be too large to be entrained through the intake slots unless crushed. While crushing is possible, studies using wedge-wire screen intakes have shown that the eggs would be more likely to roll along the intake surface. Eventually, they would roll off the intake and could continue their descent to the river bottom. (Finding 86).

Nor would the intake have a serious impact on larval sturgeon. While there is some evidence that larvae less than about 21 mm in length or 19 days of age could be entrained if they came into contact with the intake, such contact with the intake is unlikely. The larvae have a very strong benthic orientation and, hence, remain extremely close to the river bottom for up to approximately 40 days. Since the bottom of the intake screens would be two feet above the river bottom, young larvae would be unlikely to move high enough in the water column to encounter the screens. In addition, sturgeon larvae demonstrate strong swimming ability. This swimming ability, which gets stronger as the larvae get older, should be sufficient to enable larvae which have outgrown their benthic orientation to escape from the pull of the proposed intake since the intake velocity would not exceed 0.5 fps. Therefore, sturgeon larvae should not suffer significant amounts of impingement or entrainment by the proposed intake even if they occur at Point Pleasant. (Findings 26, 27, 87, 88, 89, 90, 91, 92, 93).

Juvenile sturgeon are even larger and better swimmers than are sturgeon larvae. If they were present at Point Pleasant, it is even less likely that they would be adversely impacted by the intake than it is that larvae could be so impacted. (Finding 94).

In summary, the Board doubts that shortnose sturgeon spawn at Point Pleasant. Even if they do, however, there would be no significant impact from the intake at any life stage of sturgeon.

Insofar as American shad are concerned, there is no doubt that they occur in the Delaware River. Adults pass through the Point Pleasant area during their migration upstream to spawn; juveniles pass through Point Pleasant when migrating out to sea. Juveniles, in fact, use the pool formed by the Lumberville wing dam as a nursery area. (Findings 95, 96).

Witnesses for all the parties including Del-Aware agreed that the intake would not impinge or entrain adult shad. (Finding 95). There was more concern about the intake affecting juveniles.

In assessing the potential for impacts on juvenile shad, the Board first had to determine exactly when the juvenile stage begins for shad since the witnesses appeared to use the term in different ways. In this opinion, we are defining the juvenile stage as beginning approximately 30 days after the eggs hatch, when transformation occurs and the fish take on adult characteristics. At this time the fish would be approximately 28 to 30 mm long. (Finding 97). This is the definition of the juvenile stage which was given by Joseph Miller, a fishery biologist with the U.S. Fish and Wildlife Service, and we have adopted it because, of all the witnesses who appeared before us, Mr. Miller had done the most extensive work on American shad in the Delaware River. We believe that Mr. Miller is the best source we had on characteristics of shad in the Delaware. We appreciate the efforts of Del-Aware in presenting him and other Federal and Pennsylvania fisheries experts as witnesses in this proceeding.

Juvenile shad would be protected from entrainment by the intake because of their size. (Finding 98). The potential problems for juvenile shad were impingement and descaling. It was conceded, however, that impingement would not be a problem if the intake velocity would not exceed 0.5 fps since the juveniles would have a strong enough swimming ability to escape the intake's pull. (Finding 99). As we have previously explained in this Opinion, we expect that the intake velocity would not exceed 0.5 fps. Therefore, we conclude the intake should not cause impingement of healthy juvenile shad.

The descaling problem which was alleged would occur if shad between 25 and 40 mm long were drawn against the intake and then used their swimming ability to escape. Some witnesses were concerned that this would cause the fish to lose scales and would eventually kill them. (Finding 100).

There are a number of factors which we believe render the potential for such descaling inconsequential. We note that the potential for descaling has not in any way been connected with this particular intake. The witnesses who raised this concern did not indicate that the problem would be worse if the intake were placed as proposed than it would be if the intake were placed elsewhere. These witnesses admitted that the same type of descaling could occur if a shad brushed against a rock. (Finding 100). This concern would, therefore, not appear to be connected in any way with the changes in the intake proposal which led to this contention being admitted.

We are also not certain how valid the concern would be. If shad can be killed by brushing against rocks, let alone against existing intakes in the river, we would expect to be presented evidence that large numbers of shad have died in this way. Yet we were presented no such evidence.

Even if such descaling would result from contact with the intake, however, we conclude that it would not cause a serious impact on the shad population in the river. The zone of influence of this intake relative to the total cross-section of the river at Point Pleasant is very small. One witness indicated that eggs and larvae, both less mobile than juveniles, would be in danger only if they passed with 2 inches of the intake screen. (Findings 27, 101). Thus, unless the juvenile shad population were concentrated extremely near the intake screens when passing Point Pleasant (and we have been presented no evidence in support of that unlikely circumstance), the percentage of the juvenile shad population which could be affected in this way would be exceedingly small. Even if all juvenile shad which passed within two inches of the intake were lost due to descaling, this would be a very small proportion of the total shad population. Particularly when we consider that we have no evidence of large kills due to descaling occurring elsewhere, we simply cannot envision that there would be a detectable change in the shad population attributable to descaling caused by the proposed intake.

There was some controversy about whether shad presently spawn at Point Pleasant or are likely to spawn there in the future. It appears that shad once spawned in the Delaware River from Philadelphia to the headwaters of the river in New York. By the 1970's, however, the shad's spawning range had shrunk and spawning only occurred above the Delaware Water Gap. In the 1980's the Shad's spawning range had once again begun to expand. There was conflicting testimony on the question of whether this reexpansion meant that spawning has been occurring as far downstream as Point Pleasant. In any event, if the spawning range were to expand to its total historic length, it would include Point Pleasant. The Applicant assumed in evaluating the impact of the intake that spawning would occur at Point Pleasant in the future if it does not occur there now. (Findings 102, 104). We agree that this is an appropriate assumption.[3]

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3 The Applicant collected objects at the Point Pleasant site which could have been shad eggs, but had not analyzed them to determine whether they were in fact shad eggs. (Finding 103). In the circumstances, we are willing to assume they are shad eggs and that spawning occurs at Point Pleasant.

Because shad spawning normally occurs in the downstream third of a pool and the intake would be located in the upstream portion of the Lumberville pool, spawning probably would not occur in the immediate vicinity of the intake. However, Del-Aware was concerned that eggs and larvae spawned in the pool just above the Lumberville pool would drift into the Lumberville pool and be adversely affected by the intake. (Finding 105). Since eggs and larvae are, to a certain extent, at the mercy of the flow, this concern deserves consideration.

Shad eggs apparently have a size range between 1.1 and 3.8 mm in diameter with a mean diameter of 2.83 mm.[4] Although most shad eggs would be larger than the 2 mm width of the intake slots, they could be crushed and forced into the intake. Witnesses for all parties agreed that eggs which passed sufficiently close to the proposed intake could be entrained. (Findings 106, 107).

The number of eggs passing sufficiently close to the intake slots to be entrained would, however, be limited. Shad eggs are demersal, normally sinking to the ocean bottom within 5 to 35 meters of where they are spawned. (Finding 108). Once the eggs have sunk to within 2 feet of the river bottom, they would be below the intake screens and not susceptible to entrainment. Moreover, eggs which spend the longest time

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4 The Staff gave a size range between 2.1 and 3.8 mm. To be conservative, we are utilizing the Applicant's figures which provide for smaller eggs.

in the water column and, hence, are most likely to encounter the intake are less likely to produce larvae even if not entrained. (Finding 110). The average egg has a less than one percent chance of hatching even if it is not affected by the intake. (Finding 109). This would tend to limit the effect that egg entrainment would have on the shad population.

Shad larvae could also be subjected to entrainment and impingement. The larvae are approximately 6 to 10 mm long when hatched and reach 20 mm at 17 or 18 days of age. They would be approximately 30 mm long at the time transformation occurs and they become juveniles. (Findings 97, 111). Until they reach 20 mm in length, the danger would be entrainment. After that time, it would be impingement. (Findings 116, 117).

Shad larvae display a behavior pattern of repeatedly rising to the river surface and then sinking to the river bottom. This means they can be found relatively uniformly throughout the water column. (Findings 112, 113). Therefore, unlike for eggs, it cannot be assumed that the potential exposure time for the larvae is limited. At worst, however, with the larvae distributed uniformly through the water column, the percentage of the larvae passing Point Pleasant which would be adversely affected would equal the percentage of the flow withdrawn. (Finding 118). At the lowest flow anticipated in the future, 2500 cfs, the intake operating at its maximum capacity would withdraw less than 6 percent of the flow. (Findings 17, 71). Actually, however, during the months when larvae could be present at Point Pleasant, flows this low are rather uncommon. (Findings 68, 69, 70, 119). Therefore, the percent of the flow which would be withdrawn would be less. For average flow conditions, less than 2 percent of the water passing the site would be removed by the intake. Therefore, less than 2 percent of the larvae passing Point Pleasant would be adversely affected by the intake. (Finding 120).

Avoidance behavior by the larvae could further reduce the percent impacted. Although larvae shorter than 20 to 25 mm are largely at the mercy of the current, even recently hatched larvae are capable of some mobility and avoidance response. Studies on larvae of other species of fish, some closely related to shad, have shown that larvae have some ability to resist intakes beginning when they are 10 to 15 mm long. (Findings 114, 115). This means that some larvae subjected to the intake's pull would be able to resist it and avoid becoming impinged or entrained. The fact that the intake's pull drops dramatically a very small distance from the intake screen (Finding 27), should facilitate escape by larvae located a short distance from the screens even if those larvae have not yet developed strong swimming ability. Indeed, a witness for Del-Aware indicated his concern was limited to larvae within two inches of the intake screens. (Finding 101).

Although the percent of shad eggs and larvae affected by the intake would be small, the fact remains that some impingement and entrainment is forseeable. This does not mean that the intake's impact would be significant.

There are hundreds of pools in the Delaware River which serve as spawning grounds for shad. (Finding 121). The percentage of the total Delaware River eggs and larvae population which would be affected would be considerably lower than the already low percentages of eggs and larvae affected at Point Pleasant.

Although Del-Aware was concerned that the loss of any shad eggs or larvae would have a detrimental effect on the ability of the shad to repopulate their historic spawning grounds (Finding 122), we cannot agree. Shad populations are currently expanding although spawning at Point Pleasant, if it occurs, is limited. Given the fact that of the 100,000 to 500,000 eggs laid by a female shad (Finding 109), only three eggs need to reach adulthood to continue population gains, the loss of something less than 2 percent of those eggs and the resulting larvae at Point Pleasant could not reasonably be expected to prevent further population expansion. Rather, we find that the intake will not have a significantly adverse effect on the shad population in the Delaware River or the ability of that population to expand. (Finding 123).

We conclude that the intake, as relocated, would have no significant adverse effect on the Delaware River populations of either American shad or shortnose sturgeon. Therefore, there would be no benefit to these species from moving the intake further from the west shore of the river or from placing the intake upstream or downstream of the presently proposed location. (Finding 124). The insignificant impact of the presently proposed location would certainly be no greater than that of the shoreline location evaluated at the construction permit stage, and would very probably be less.

F. Impacts Of The Intake on Recreation

1. Effects on Boating, Rafting, and Tubing[5]

Contentions V-15 and V-16a (in part) included an allegation that the intake would adversely affect a major boating and recreation area. (Finding 6). Some of Del-Aware's witnesses indicated that they were concerned that the intake would be a hazard to people utilizing the area for boating, rafting, or tubing. (Finding 125). The purported danger was apparently that they would be injured either by direct contact with the intake or by becoming hooked on fishing lures which may have been caught on the intake.

The intake would be covered by four feet of water even at a comparatively low flow of 3000 cfs (Finding 15). This should be sufficient depth to prevent the intake from being a hazard. Tubers may float through areas where the water is no deeper than a foot or eighteen inches. (Finding 127). They are more likely to contact the river bottom in such shallow water than they are to hit the intake. The river

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5 "Tubing" involves floating down the river while sitting in or holding onto an inner tube.

in the vicinity of Point Pleasant contains rocks. (Finding 126).[6] Therefore, people in boats or rafts would be no more likely to contact the intake than they would be to contact rocks.

There would be no serious danger of injury from fishing hooks caught on the intake. Although fishing lures have been lost because they have become entangled with objects in the river, no witness was aware of any incident in which someone had been injured by these lures. (Finding 126). Lures caught on the intake would not be any more likely to cause injury than would those which have been caught on other objects, apparently without causing injuries.

In summary, the intake would not increase the risk of injury to boaters, rafters or tubers beyond that they already experience.

2. Effects on Fishing

Del-Aware witnesses were concerned that the intake would have an adverse impact on fishing at what they described as one of the six best shore fishing sites on the Pennsylvania side of the Delaware River between Trenton and Easton. Point Pleasant, these witnesses testified,

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6 Although no testimony specifically addressed the fact, the Board during its site visit observed that some of the rocks out toward the middle of the river were within four feet of the surface even though the river flow was not particularly low.

is the second best spot for shore fishing for shad in that reach of the river. (Finding 128). The reason for Point Pleasant's superiority as a fishing spot for shad is believed to be that shad, which travel in a relatively narrow section of the river during their upstream migration, are closer to the Pennsylvania shore and within casting distance at that point. (Finding 129).

The concern was that shad would shy away from the intake and would alter their migratory path in such a way that it would no longer be possible to reach them when casting from shore. The intake screens would begin two feet above the river bottom while the shad travel within one foot of the bottom. Therefore, the intake array should not directly impede the shad's route. The witnesses were concerned, however, that the shad, which they described as "spooky", would avoid passing beneath the intake. (Finding 130).

The Board concludes that there is no evidence that the intake would have a detrimental effect on the Pennsylvania shad fishery. No evidence was presented that the intake will actually be located in a normal pathway of the migrating shad, since no particular pathway was known. As the witnesses conceded, an intake located elsewhere in the river could have a more serious impact on shad fishing. While a shoreline location for the intake would be least likely to cause the shad to modify their migratory path, such a location has other drawbacks which would outweigh its possible benefits in terms of possibly not scaring fish beyond casting distance from the Pennsylvania shore. (Finding 131).

If, in fact, the intake were to be located in the path of the shad and they were to change their pathway to avoid it, it is equally possible that they would move towards the Pennsylvania shore as that they would move away from it. (Finding 132). Thus, the intake could actually improve the Pennsylvania shore shad fishing rather than harming it.

G. Impacts On The Proposed Historic District

Contention V-16a concerns the impacts of noise and maintenance related to operation of the intake on the Point Pleasant proposed historic district. (Finding 133). Although the Point Pleasant district has not, as yet, been listed on the National Register of Historic Places, it has been declared eligible for such listing by the keeper of the National Register. The district's significance is related to its preservation of the atmosphere and environment of a nineteenth century canal town. (Finding 134).

Under the National Historic Preservation Act, 16 U.S.C. §§ 470-470(n) (1976 & Supp.), as interpreted by the Advisory Council on Historic Preservation in its regulations, noises which are out of character with an historic property or which would significantly alter the property's setting may constitute adverse effects which require consideration by federal agencies involved in the projects causing them. (Finding 135). Therefore, adverse noise effects on the proposed historic district resulting from operation of the intake must be considered.

In compliance with the Act, the Pennsylvania State Historic Preservation Officer and the Advisory Council on Historic Preservation have been consulted concerning the Point Pleasant diversion. Neither has identified noise from the proposed intake and pumping station as an adverse impact on the proposed historic district. (Finding 136).

Although the National Historic Preservation Act has been complied with, that does not preclude the need to comply with NEPA with regard to impacts on historic and cultural aspects of the environment. See Preservation Coalition, Inc. v. Pierce, 667 F.2d 851, 858-59 (9th Cir. 1982). Therefore, noise impacts on the proposed historic district must be evaluated and, if necessary, mitigation measures undertaken.

A survey to determine ambient noise levels was done on the pumping station property during 1981. The noise level was measured at one point on the site (a point 30 feet from the southern property line and 100 feet east of the road). This measurement was considered representative of the ambient noise level at any point on the property since the ambient noise level would not be expected to vary greatly over a small distance. (Findings 137, 139).

Ambient noise measurements are made by taking sound readings which exclude nearby transient noise sources. Generally the low background noise level is defined as the lowest noise level measured over a fifteen minute period. (Finding 138).

The Applicant evaluated the impact of the anticipated noise from the proposed pumping station by comparing it to a background noise level which would be exceeded ninety percent of the time (L_{90} sound level). In effect, PECo used for comparison a value which included noise levels at all frequencies. However, PECo's value was an A-weighted noise level, meaning that it was measured by an instrument which was most sensitive to those frequencies to which the human ear is most sensitive. Hence, the value, while accurate, deemphasized noise levels at particular frequencies higher or lower than those best perceived by the human ear. (Findings 140, 141).

The Staff's witness on noise presented a convincing case why the A-weighted L_{90} sound level is not appropriate for determining the noise impacts from the pumping station. (Finding 142). People may perceive and be annoyed by noises which exceed the background noise level at particular frequencies, yet the L_{90} sound level may mask that effect by deemphasizing those frequencies. Indeed, the noise impact of the transformers associated with the pumping station would be deemphasized in just such a manner if the A-weighted L_{90} sound level were used for comparison. (Finding 142).

The Staff's witness suggested a different method of determining noise impacts which would avoid the problems of deemphasizing particular, possibly annoying, noises. He advocated determining the masking level of the ambient noise at each frequency which is a component of the noise whose impacts are being evaluated. The masking level is calculated from the sound level at the particular frequency and at frequencies within approximately 20 hertz (Hz) of the frequency in question. (Finding 143). The noise being evaluated is then compared to the masking level at each of its frequency components. Studies have shown that if the noise being evaluated is 3 decibels (dB) above the masking level at a particular frequency, most people will be able to perceive it. If, at any frequency, it is 5 dB above the masking level, people will complain of accoustical discomfort and annoyance. (Finding 144).

In order to calculate masking levels, one must know the background noise levels at particular frequencies, i.e., have ambient octave band sound pressure levels. The Applicant had daytime octave band sound pressure levels. However, the Staff's witness indicated that ambient noise levels are ordinarily measured at night, between midnight and 4:00 a.m. He indicated he would expect nighttime noise levels to be somewhat less than those measured during the day, and therefore, for his evaluation he estimated that ambient nighttime noise levels would be 3 dB lower than the measured daytime ones. (Finding 139).

Noise sources associated with the proposed intake would be the pumps and other equipment within the pumping station and the transformers immediately outside of it. Although emergency generators were once planned, they have been deleted and, therefore, are not a potential noise source. (Findings 145, 146, 147, 153).

The pumphouse would contain four pumps driven by electrical motors, the fourth of which would not be installed until between the years 1990 and 2000. The pumps would have a sound level rating of no more than 86 dB. (Finding 145). Ventilating equipment and small air compressors would also be within the pumphouse, but their noise level would be approximately 10 dB less than that contributed by the pumps. (Finding 146).

To help contain the noise, the pumphouse would be insulated and without windows. Sound attenuating designs would be used for all ventilating systems. (Finding 148).[7] The pumphouse structure should sufficiently attenuate any pump and motor noise from inside it so that any noise outside it should be much lower than the ambient sound level. (Finding 150). The noise would be further attenuated at greater

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7 At the time he testified, the Staff's witness was uncertain about the air intake location and sound specifications for the pumphouse doors. He testified, however, that it would be well within the state-of-the-art to remedy any problem of noise transmission to the outside by these pathways. (Finding 149).

distances from the noise source. (Finding 151). As a result of attenuation by the pumphouse structure and as a result of distance from the pumphouse, the noise from equipment within the pumphouse should be at or below ambient noise levels at the closest site property line. (Finding 152).

Two transformers would be located outside the pumphouse, immediately adjacent to it on the river side. They would be 15 to 20 feet apart and separated by a firewall. (Finding 153). The transformers would be rated as producing 57 dB (A-weighted). (Finding 154). Noise from the transformers would be composed of discrete frequencies with fundamentals occurring at 120 Hz and multiples thereof. The fact that the transformer noise consists of discrete frequencies increases the likelihood that it will change the character of noise in the area and annoy people even if its level does not exceed the overall ambient level. (Finding 155).

No comparison has been made of the noise which would be generated by the transformers at 120, 240, 360 and 480 Hz with the masking levels at those frequencies. The Staff's witness, who advocated the technique, had not at the time of the hearing received sufficient information on the transformers selected to make this comparison. Nor were we presented with such a comparison by the Applicant. The Staff's witness indicated, however, that based on the information he did have, he believed the transformer noise would be audible beyond the boundaries of the pumphouse site at those frequencies at which it has fundamentals. (Findings 156, 157).

The Staff's witness focused his concern on the four residences near the pumphouse property. Specifically, he felt the noise would be audible at what were designated Residences 1 and 4. Of these two, Residence 4 is apparently closer to the transformers, and therefore would suffer a greater noise impact. (Finding 158).

Technology exists, basically in the form of sound barriers or sound walls, which could be used to eliminate any audible offsite noise. This technology could be utilized at the pumping station if the station were built and operational and noise reduction proved necessary. However, for economic reasons, there is no plan to install sound walls unless they prove necessary. (Findings 159, 160).

The Board is imposing a condition which will require that, if the pumping station is constructed and operated, tests shall be performed to ascertain whether the transformers will cause audible noise away from the pumping station property. The methodology recommended by the Staff's witness is to be used in making this determination. If these tests show that noise is audible offsite, mitigation measures are required to minimize the noise impact. Specifically, the Board requires that within one month after the pumping station begins operation, the Applicant shall carry out the following noise measurements and calculations. Measurements shall be made between 12:00 a.m. and 4:00

a.m. at the site boundary at a point on the straight line between the transformers and Residence 4 (as shown in Policastro Testimony, ff. Tr. 1118, at Attachment 1) or at that point on the site boundary line where the maximum noise impact occurs (if that point is different). Measurements shall be obtained by reading the lowest level on the sound level meter (set on fast response) which is repeated several times (i.e., the mean minimum). At the specified location or locations the following measurements shall be made:

A. Measurement of the octave band sound pressure levels. From these measurements, the masking level shall be computed for transformer fundamental frequencies of 120, 240, 360, and 480 Hz.

B. Measurements at the 1/3 octave bands for those four bands containing the fundamental frequencies.

The results of these measurements and computations shall be reported to the Staff. The noise will be considered audible if the measured sound pressure level and the 1/3 octave band containing the fundamental frequency (from measurement B) is greater than the masking level computed (from measurement A) for that frequency. If any of the four transformer fundamentals is found to be audible, measures shall be taken which render that fundamental (those fundamentals) inaudible.

In the event such measures are necessary, they shall be undertaken promptly. If such measures are necessary or if additional equipment which could increase the noise level is added, the measurements and computations described above shall be repeated and the results reported to the Staff.

These measures should assure that there will be no adverse impact on the proposed historic district from noise impacts related to operation of the intake.

In addition to noise directly related to operation of the intake, Contention V-16a concerns the impacts resulting from dredging maintenance for the intake. (Finding 133). Although the contention was, on its face limited to dredging, the testimony presented primarily concerned other maintenance work. We have also evaluated the impacts associated with that work.

Insofar as dredging is concerned, the evidence suggests that none would be necessary. Essentially the velocity of the river passing the intake should keep material from building up beneath the intake. Comparison of river bottom measurements made fourteen years apart indicates that in the past the river velocity has prevented any substantial deposition of material. The rip-rap which would be placed under the intake should assure that this lack of deposition would continue. (Findings 161, 162).

Del-Aware's witnesses suggested that the intake would be damaged if debris and ice were swept against it and that this would require substantial noisy repair work. (Finding 163). We conclude that such damage would be unlikely and that, if it were to occur, it could be repaired without causing any substantial adverse impacts on the proposed historic district.

Del-Aware's own witness indicated that ice and/or debris are found in the river after rains. Rain, of course, increases the flow in the river. McNutt's testimony about the river's level when he has seen ice and debris floating in it confirms that this occurs at relatively high flows. (Finding 164). Since the top of the intake would be under four feet of water even at a comparatively low flow of 3000 cfs (Finding 15), the clearance provided at even higher flows should be sufficient to insure that the ice and debris, floating on the river's surface, would not come into contact with the intake.

The Applicant also plans to provide guard posts at the upstream end of the intake structure. These should deflect ice and debris and would assist in preventing the intake from being damaged in the manner hypothesized. (Finding 165).

The Applicant also indicated means by which the intake could be repaired with a minimum of noise in the unlikely event it was damaged. Debris accumulated against the intake could be removed from a boat or by a diver. (Finding 166). Neither of these should cause intrusive noise.

Damage to an intake screen could be repaired underwater or by removing and replacing the screen in question. Removal of a screen might require a barge and, perhaps, a crane. (Findings 167, 168). While a crane might entail some noise, it appears that it would be a repair method of last resort for damage which is unlikely to occur. Any such noise would be a remote possibility and of short duration if it were necessary.

We conclude that maintenance, either dredging or to repair damage caused by ice or debris is unlikely to be necessary. If such maintenance should occasionally prove necessary, it would not cause noise impacts adversely affecting the Point Pleasant proposed historic district.

The matters examined during the evidentiary hearing which are not discussed in this Opinion were considered by the Board and found either to be without merit or not to affect our decision herein. Findings of Fact and Conclusions of Law which are annexed hereto are incorporated in the Opinion by reference as if set forth at length. In preparing its Findings of Fact and Conclusions of Law, the Board reviewed and considered the entire record and the Findings of Fact and Conclusions of Law proposed by the parties. Those proposed findings not incorporated directly or inferentially in this Initial Decision are rejected as being unsupported by the record of the case or as being unnecessary to the rendering of this decision.

II. FINDINGS OF FACT

A. Background

1. This partial initial decision concerns alleged operational impacts of the supplementary cooling water system which is proposed to convey water from the Delaware River for use at the Philadelphia Electric Company's Limerick Generating Station. 47 Fed. Reg. 38657 (1982).

2. The parties who participated in the hearing are the Philadelphia Electric Company (PECo or Applicant), Del-Aware Unlimited, Inc. (Del-Aware), and the Staff of the United States Nuclear Regulatory Commission (Staff). Tr. 741-42. Although other intervenors and governmental agencies are participating in the adjudication concerning issuance of operating licenses for Limerick, they have not been involved in the proceedings which are the subject of this partial initial decision.

3. This Licensing Board has jurisdiction over the issues decided in this partial initial decision pursuant to the Atomic Energy Act of 1954, as amended, § 191, 42 U.S.C. § 2241 (1976); the National Environmental Policy Act, § 102, 42 U.S.C. § 4332 (1976); 10 C.F.R. § 2.721 (1982); Notice of Evidentiary Hearing on Supplementary Cooling Water System Issues, 47 Fed. Reg. 38657 (1982); Establishment of Atomic

Safety and Licensing Board to Preside in Proceeding, 46 Fed. Reg. 45715 (1981); Notice of Opportunity for Hearing, 46 Fed. Reg. 42557 (1981).

4. The Applicant proposes to supply supplementary cooling water to Limerick by means of the Point Pleasant diversion. The diversion project, involving several components, would withdraw a maximum of 95 million gallons of water per day (MGD) from the Delaware River. Of this, up to 46 MGD would be used as cooling water for Limerick. The remainder would be utilized by the Neshaminy Water Resources Authority (NWRA) to supply water for Bucks and Montgomery counties in Pennsylvania. Special Prehearing Conference Order, LBP-82-43A, 15 NRC 1423, 1461-63 (1982) (SPCO); Applicant's Testimony on "Water Issues," ff. Tr. 949, at 5; Applicant's Ex. 1A at Response to Question E291.4.

5. The two contentions which are addressed in this partial initial decision concern the potential operational impacts of the intake structure in the Delaware River and its associated pumping station. A third contention, relating to impacts of a reservoir which would be a part of the diversion, was withdrawn by Del-Aware pursuant to a stipulation among the parties during the course of the hearing. Tr. 2370-71; Stipulation Concerning Contention V-16b, ff. Tr. 2371. The remaining components of the Point Pleasant diversion, insofar as they would be used to convey supplemental cooling water to Limerick, were not at issue in this adjudication.

6. Contentions V-15 and V-16a (in part), as litigated in this proceeding, state:

> The intake will be relocated such that it will have significant adverse impact on American Shad and Shortnose Sturgeon. The relocation will adversely affect a major fish resource and boating and recreation area due to draw-down of the pool.

See SPCO, 15 NRC at 1479.

B. Location and Description of Proposed Intake

7. In July, 1980, the proposed location for the intake in the Delaware River was changed from a position along the Pennsylvania shoreline at Point Pleasant to one located out in the river approximately 200 feet from the west, Pennsylvania, shoreline. Applicant's Testimony, ff. Tr. 949, at 2-3; Applicant's Ex. 2 at 1.

8. In January, 1982 the proposed position for the intake was moved an additional 45 feet from the west shoreline, without changing the alignment of the intake pipes appreciably. The reason for moving the screen was to take advantage of the higher river velocities farther out into the river. Applicant's Testimony, ff. Tr. 949, at 2-3; Bourquard at Tr. 1421-22.

9. The intake has been described as being located in the "pool" of the Delaware River formed by the Lumberville wing dam. The length of the "pool" as understood in this proceeding, extends upriver from the

Lumberville wing dam to the riffle or rapids near the mouth of the Tohickon Creek. The intake would be located in the Delaware River at river mile 157.2 near the upstream limit of the Lumberville pool in the lower section of the swift water passing the mouth of the Tohickon Creek. The intake would be about 800 feet downriver of the confluence of Tohickon Creek and the Delaware River and approximately 1.5 miles upriver of the Lumberville wing dam. Applicant's Testimony, ff. Tr. 949, at 6; Testimony of Dr. Michael T. Masnik, ff. Tr. 3504, at 4; Applicant's Ex. 4.

10. The type of intake screen planned was also changed. When the shoreline location was proposed, the intake was planned with a vertical traveling screen. Applicant's Testimony, ff. Tr. 949, at 2-3; Applicant's Ex. 2 at 1. The present design calls for a passive wedge-wire screen structure. There would be two parallel rows of screens located seven feet apart. Each row would consist of six cylindrical screen sections placed end-to-end with space between the cylinders, aligned generally parallel to the river. The cylinders would be 10 feet 4 inches long and have a 40 inch diameter. Each cylinder would have two 40 inch long sections of screen with a 44 inch solid piece between them. The lead and trailing screens would be protected by conical end pieces. Each row would be about 75 feet in total length. Applicant's Testimony, ff. Tr. 949, at 3-4 and Page 2 of Exhibit A; Masnik Testimony, ff. Tr. 3504, at 4-5.

11. The screening on the intake would be made of helically welded wedge-wire wound circumferentially around internal supports spaced about 6 inches apart. The narrow portion of the wedge-wire would face inward so that the exterior screen surface would be relatively smooth and flat. The screen openings would be slots 2 mm in width. Applicant's Testimony, ff. Tr. 949, at 4; Masnik Testimony, ff. Tr. 3504, at 4-5.

12. A passive wedge-wire screen intake utilizes state-of-the-art technology. Witnesses for all of the parties, including Del-Aware, agreed that the presently proposed intake location and design is preferable to the originally contemplated shoreline intake with a vertical traveling screen. Applicant's Testimony, ff. Tr. 949, at 3, 6; Boyer at Tr. 1350; Brundage at Tr. 2996; Miller at Tr. 3156-57; McCoy at Tr. 3302; Masnik at Tr. 3982.

13. The intake design is such that water would flow into the screens around their entire circumference. Applicant's Testimony, ff. Tr. 949, at 4. The design would be such that through-slot water velocities would be nearly uniform over the entire screen surface. Masnik Testimony, ff. Tr. 3504, at 5.

14. The intake would be provided with an air backflush system to assist in keeping the screens free from debris. The Applicant anticipates that the system would be operated about once a week except during the relatively short period when fallen leaves are in the river. During that period it is anticipated that the system would be operated

once or twice a day. Applicant's Testimony, ff. Tr. 949, at 4-5; Bourquard at Tr. 2435-36, 2557-8, 2561; Boyer at 2561.

15. The intake would be located with the lowest part of its screens two feet above the river bottom. At river flows of about 3,000 cubic feet per second (cfs), the intake would be in water approximately ten feet deep. Under those conditions, the water surface would be approximately four feet above the top of the intake. Applicant's Testimony, ff. Tr. 949, at 4, 13; Masnik Testimony, following Tr. 3504, at 4-5; Applicant's Ex. 2 at 4-5.

16. For a river flow of 3000 cfs, even with the proposed intake operating at its maximum pumping rate, the water level at Point Pleasant would drop by less than an inch. Testimony of Rex. G. Wescott, ff. Tr. 3490, at 3; Applicant's Testimony, ff. Tr. 949, at 13. See also, Phillippe at Tr. 3807-08. This amount of drawdown would be barely perceptible to the human eye and would have a totally negligible effect on the overall water level in the pool. Masnik Testimony, ff. Tr. 3504, at 25. The changes in the intake's proposed location would not affect the amount of drawdown since the intake would still be in the same pool. Wescott Testimony at 2.

17. If water were being withdrawn at the maximum rate of 95 MGD, at a river flow of 3000 cfs, 4.9% of the flow would be withdrawn. At a flow of 2500 cfs, the withdrawal of 95 MGD (147 cfs) would represent a withdrawal of 5.9% of the flow. Masnik Testimony, ff. Tr. 3504, at 15;

Masnik at Tr. 3557; Harmon at Tr. 8398. Emery at Tr. 2064. At the lowest flow historically recorded, which occurred in October, 1963, the intake operating at its maximum capacity would have withdrawn 12% of the 1180 cfs flow. Direct Testimony of Richard W. McCoy, ff. Tr. 3046, at Table 1; McCoy at 3211-12.

18. Riprap would be placed on the river bottom beneath the intake over an area approximately 24 x 90 feet. The riprap would be approximately two feet thick and would be composed of large stones (about 12 inches on a side). The contours of the bottom where the riprap would be placed would be restored to roughly what they were before the intake was constructed. Applicant's Testimony, ff. Tr. 949, at 16; Bourquard at Tr. 2551-54, 2556.

C. The Point Pleasant Eddy

19. An eddy is a current of water, running contrary to the main current (especially a current moving circularly). Applicant's Testimony, ff. Tr. 949, at 6; Bourquard at Tr. 2524.

20. During periods of relatively low flow (below 5000-6000 cfs) the Delaware River at River Mile 157.2 (the proposed intake location) can be described as consisting of two parts: (1) a main channel or portion of relatively high flow velocity and (2) a slack water portion, to the Pennsylvania shore side of the main channel, containing a

clockwise moving body of water referred to as an eddy. Applicant's Testimony, ff. Tr. 949, at 6.

21. The eddy forms as a result of a rocky bar immediately downstream of the Tohickon Creek which causes a slack water area downriver of the bar on the Pennsylvania side of the river. Depending upon the river flow, water may or may not pass over the bar, and the amount of water flowing over the bar controls the size and location of the eddy. Harmon at Tr. 1406; Boyer at Tr. 1404, 1425, 1427; Plevyak at Tr. 1936.

22. With increasing river flows, the bar is covered by more and more water, and the eddy is forced downstream and shrinks in width away from the middle of the river. At particularly high flows, the eddy may cease to exist. Harmon at Tr. 1406; Boyer at Tr. 1404, 2766-7; Bourquard at Tr. 2614; Wescott at Tr. 3938. As the water flow drops below 5000 to 6000 cfs, the bar gradually starts to become exposed and the eddy expands upstream and widens out from the Pennsylvania shore. When the full length of the bar is exposed (at flows of approximately 3000 to 4000 cfs), the eddy achieves its maximum width in terms of the distance it extends from the Pennsylvania shore. Bourquard at 2614-15; McCoy at Tr. 3262; Kaufmann at 2098-99; Harmon at Tr. 1406, 1410; Boyer at Tr. 1413.

23. At its maximum width the eddy does not appear to extend past a point designated by the Applicant as Station 7 + 75. Bourquard at

Tr. 1405. Essentially, this designation signifies a distance of 775 feet from a point along the river road selected by the Applicant to be used as a point of reference in determining locations. This "station" system of designating locations is designed to avoid describing distances into the river in relation to the shore since the shoreline will change with changing flows. Bourquard at Tr. 2193; Applicant's Ex. 4.

24. Del-Aware alleged that the intake would be located in or would draw water from the eddy and that this would increase the risk of harm to developmental stages of American shad and shortnose sturgeon. Del-Aware theorized that the slow clockwise circulation in the eddy would cause them to be exposed to the intake repeatedly and for a longer period of time. Kaufmann at Tr. 1959, 2068-70; Emery at Tr. 2067, Miller at Tr. 3054.

25. The center of the proposed intake would be located at Station 8 + 62, or about 87 feet further out into the river than the estimated edge of the fully developed eddy. Harmon at Tr. 1410; Boyer at Tr. 1413, 1424. Witnesses for all the parties agreed that the proposed intake would not be in the eddy. Applicant's Testimony, ff. Tr. 949, at 6; Plevyak at Tr. 1940; Wescott at Tr. 3937, 3941, 3965; Harmon at Tr. 2573, Bourquard at Tr. 2574; Phillippe at Tr. 3756.

D. Intake Velocity

26. The maximum velocity through the intake screens would be 0.5 feet per second (fps), with an average velocity of 0.35 fps. Applicant's Testimony, ff. Tr. 949, at 5; Applicant's Ex. 2 at 1; Boyer at Tr. 1351; Emery at Tr. 1768, 1774.

27. The design of the intake is such that the speed at which water would be drawn toward the intake would decrease very rapidly as the distance from the screen surface increases. At a distance of one foot from the screen, the average velocity toward the screen would fall to 0.071 fps. At five feet, the Applicant calculated that the average velocity toward the screen would have decreased to 0.011 fps. The velocity at ten feet was calculated to be 0.0037 fps. Applicant's Testimony, ff. Tr. 949, at 5; Masnik Testimony, ff. Tr. 3504, at 5; Boyer at Tr. 1363; Harmon at Tr. 2899.

28. Del-Aware's witnesses expressed concern that the screens could become clogged, causing the velocity through the slots to increase. The witnesses suggested that biofouling or fishing hooks could cause clogging. Direct Testimony of Charles Emery, ff. Tr. 1736, at 19; Kaufmann at Tr. 1879-80; McCoy at Tr. 3165-66, 3292-93; Miller at Tr. 3291-92.

29. Del-Aware's witness, Charles Emery, testified that a wedge-wire screen is less susceptible to clogging than most others and

that the intake's proposed position in the river would make the screens less susceptible to clogging. Applicant's witnesses testified that they considered biofouling, other than by leaves, unlikely to occur because of the absence of biofouling organisms in the Delaware River. If leaves or frazil ice were to accumulate on the screens, the Applicant indicated that they would be removed by the air backflush system. The intake location is such that contact with fishing hooks would be minimized. Embedded hooks, if any, could be removed by a diver. Emery at Tr. 1770-71, 1815, 1884; Harmon at Tr. 2585-86; Boyer at Tr. 2537-38, 2557-58; Bourquard at Tr. 2436-37, 2557-61, 2820-21; Dickinson at Tr. 2854-55.

E. Ratio of Bypass Velocity to Intake Velocity

30. Bypass velocity is the speed of the river water passing directly in front of and parallel to the long axis of the intake. A high ratio of the bypass velocity to the screen intake velocity is one of the factors that may enhance the protective value of an intake screen in reducing entrainment and impingement of aquatic life. Harmon at Tr. 2401, 2519, 2893; Brundage at Tr. 2932-33, 2939, 2944; McCoy at Tr. 3302; Miller at Tr. 3311; Emery at Tr. 2064.

31. Based on a study by Hanson and upon experience with vertical traveling screens, it has been said that a ratio of bypass velocity to screen intake velocity of a minimum of 2 to 1 is considered optimal with

respect to minimizing impingement and entrainment problems at wedgewire intake screens. Masnik Testimony, ff. Tr. 3504, at 18; Brundage at Tr. 2932; McCoy at Tr. 3351; Harmon at Tr. 2580-81. This 2 to 1 ratio would exist for the proposed intake operating at full capacity if the river velocity were 1.0 fps. Brundage at Tr. 2939.

32. Some witnesses suggested that field trials have not seemed to support the theory that a 2 to 1 ratio of bypass velocity to intake velocity is important. Brundage at Tr. 2978; Masnik at Tr. 3587, 4028.

33. Passive wedge-wire screens provide considerable protection from impingement and entrainment in comparison to traveling screens even at a 1 to 1 bypass to intake velocity ratio or in the absence of any bypass velocity. Harmon at Tr. 2359, 2397, 2582, 2851; Boyer at Tr. 2672, 2804-05. There is negligible difference between the protection afforded by a passive screen with a 2 to 1 bypass ratio as compared to a passive screen with a 1 to 1 ratio. Harmon at Tr. 2399-2400, 2853.

34. The type of fish to be protected is a consideration in determining whether a higher bypass to intake velocity ratio is beneficial for a particular wedge-wire intake screen. Harmon at Tr. 2359. There would be no biologically significant impact on either shortnose sturgeon or American shad from the proposed intake even if there were no bypass velocity. Harmon at Tr. 2827; Masnik at Tr. 4025. Bypass velocity, and the ratio of bypass velocity to intake velocity are of little

significance in providing protection to these two species. Harmon at 2826; Brundage at Tr. 2957-58.

F. Applicant's Velocity Measurements

35. Velocity measurements made by Applicant at the intake site on November 7, 1980, with a river flow of approximately 3000 cfs and a water surface elevation of 70.8 feet, indicated that the river velocity at the location and depth of the intake was at or in excess of the 1.0 fps required to provide a 2 to 1 bypass to intake velocity ratio at the maximum intake rate. (West screens - 0.98 to 1.2 fps; east screens - 1.1 to 1.35 fps; intake velocity in the range of 0.35 to 0.5 fps). Applicant's Ex. 1-A at Response to Question E240.27 (see Figures E 240.27-1 and -3); Applicant's Testimony, ff. Tr. 949, at 5.

36. Measurements taken at the intake site (Station 8 + 62) on July 23, 1981, when the flow was estimated at 4500 cfs and the river elevation was 71.4 feet, showed velocities of over 2 fps at the intake depth locations. Applicant's Ex. 1-A Response to Question E240.27 (see Figures E 240.27-2 and -3).

37. The instrument used by Applicant to measure river velocity should be accurate to within 5 percent. Phillippe at Tr. 3826.

38. A Del-Aware witness criticized the Applicant's velocity measurements because the Applicant had not recorded the direction of the

flow for which the velocity was measured. Supplemental (Rebuttal) Testimony of Johnathan Phillippe, ff. Tr. 3658, at 9.

39. The velocities measured by Applicant were maximum velocities. Harmon at Tr. 2209. There are some uncertainties as to the direction of the water flow. Based upon the bathymetry, i.e., information on the topography of the river bottom derived from measurements of water depth, the Tohickon bar and the trend toward the Pennsylvania shore (Applicant's Ex. 4), it appears that the direction of the current could intersect the intake at a direction as great as 20-25° from parallel with the long axis of the intake structure and angling toward the Pennsylvania side. Phillippe at Tr. 3735, 3850; Wescott at Tr. 3610-3611.

40. Maximum water velocities measured at an angle to the intake can be converted to bypass velocities by multiplying them by the value of the cosine of the intersection angle. Wescott at Tr. 3611; Phillippe at Tr. 3850.

41. The cosine of an intersection angle of 15° is 0.966. The cosine of 25° is 0.906. Phillippe at Tr. 3851.

42. Del-Aware's witness contended that the Applicant's determination of distances across the river at which velocity readings were made were inaccurate because the Applicant relied on an out-of-calibra-

tion split-image rangefinder on November 7, 1980. Phillippe Suppl. Testimony, ff. Tr. 3658, at 10-11; Phillippe at Tr. 3769-70.

43. In oral testimony, the Staff indicated that it had made three separate checks of the Applicant's velocity measurements of November 7, 1980. The first check involved calculating the total flow by summing the products of measured velocities and associated cross-sectional areas. The Staff calculated a flow value of 3070 cfs as compared to Applicant's calculated flow of 2950 cfs. Wescott at Tr. 3599. See also, Wescott at Tr. 3835.

44. The second independent check concerned the location of the measurement stations and involved plotting the depth integrated velocities versus the cross section to assure that the maximum velocities were occurring at the line of maximum depth and that the profile seemed to represent what might be expected based upon the cross section of the river at the intake. As a result of that exercise, a Staff witness concluded that the distance measurements could not have been off very much. Id. at Tr. 3600.

45. The Staff's third check involved using the velocity distribution in the water column to calculate a roughness coefficient for the river channel. The calculated coefficient was then compared to coefficient values commonly associated with rocky river bottom situations. The calculated coefficient (a Mannings' "n" value) was 0.46, a very reasonable value for a rocky bottom such as that which exists at the

intake site. The favorable correlation of "n" values is an indication that the depth variation of velocity was probably accurate. Id.

46. As a result of the checks made by the Staff on Applicant's velocity and distance measurements of November 7, 1980, a Staff witness stated that he was led to believe that the velocity measurements made on November 7, 1980 are probably accurate to within a tenth of a foot per second. Wescott at Tr. 3598-99.

47. Also, as a result of these checks, the Staff witness stated he believes the distance measurements were also accurate. Wescott at Tr. 3600, 3616-17.

48. The distance measurements made on November 7, 1980 could be in error by as much as 25 feet without being apparent in the checks. Phillippe at Tr. 3835-3837; Wescott at Tr. 3925-26. In the event that an error of that magnitude occurred, it would probably have been in the direction such that the measurements were taken further out in the river than the Applicant's data indicates they were. Wescott at Tr. 3926; Phillippe at Tr. 3837.

49. Assuming arguendo that an error of up to 25 feet occurred, based on the Applicant's plot of velocity against distance for November 7, 1980, at the intake location (Station 8 + 62) at the 7 foot depth, the velocity at the actual intake location would be approximately 75 percent of the measured velocity value or a minimum of 0.82 fps.

Applicant's Ex. 1-A at Response to Question E240.27 (see Figure E 240.27-1).

50. A Staff witness questioned the accuracy of the Applicant's velocity profile from July 23, 1981 because he found the Mannings' "n" value he calculated using that data would not be reasonable for a rocky bottom like that at Point Pleasant. He noted that the probable reason for this was a single unrealistically low, and probably erroneous value at the 10 foot depth. Wescott at Tr. 3921-23.

G. Determination of Flow at Point Pleasant

51. Flows at Point Pleasant may be calculated by taking the ratio of the drainage area tributary to the river at Point Pleasant and the drainage area at Trenton and multiplying the measured flow at Trenton by that ratio. The calculated drainage area ratio is 0.97. Bourquard at Tr. 2283, 2287-88; Phillippe at Tr. 3663.

52. Applicant developed a rating curve showing water surface elevation correlated to river flow at Point Pleasant. Bourquard at Tr. 2272. The rating curve was used as the basis for river flow during times when velocity measurements were made. Phillippe Suppl. Testimony, ff. Tr. 3658, at 7; Bourquard at Tr. 2272.

53. Del-Aware argues that the rating curve fails to reflect the fact that the Lumberville Wing Dam is a hydraulic control for the water

level at the proposed intake site in the low flow ranges and states that the rating curve is not accurate for low flows. Phillippe Suppl. Testimony, ff. Tr. 3658, at 7, 8.

54. The Lumberville Wing Dam is a partial constriction of the river located approximately 1.5 miles downstream of Point Pleasant. Because it has a slot opening and its cross-sectional area changes, its impact is different at flows which overtop the side wings from its impact at flows which do not. The top of the wing walls is 70.7 ft. The slot section has a width of approximately 100 feet and a minimum weir elevation of 64.5 feet. Bourquard at Tr. 2592; Wescott Testimony, ff. Tr. 3490, at 2; Del-Aware Ex. 1B.

55. Del-Aware alleges that river flows under 5000 cfs are affected in various ways by the hydraulic control provided by the Lumberville wing dam. At flows below roughly 3000 cfs, the weir section controls; while at flows in the range of 3000 to 5000 cfs, control is provided by both the weir and the broad crested wing dam. Del-Aware states that somewhere between 5000 cfs and 8000 cfs the effects of the dam are dissipated. Because of this situation, the upper flow portions of the rating curve probably are realistic while significant problems exist below the 3500 cfs flow level. Phillippe Suppl. Testimony, ff. Tr. 3658, at 7; Phillippe at Tr. 3700.

56. A Del-Aware witness stated that the data points used to construct the rating curve fell into two distinct sets of data points,

further stating that trend lines drawn through each of the two separate clusters resulted in essentially two parallel lines above and below the 71.5 foot elevation and displaced by 600 or 700 cfs for a given elevation. The witness attributed the displacement to the effect of the weir at different flow volumes. Phillippe at Tr. 3773-74.

57. Del-Aware questioned the treatment of flows in the Delaware and Raritan canal in developing the rating curve. Phillippe Suppl. Testimony, ff. Tr. 3658, at 8.

58. The Delaware and Raritan Canal comes off the Delaware River below Point Pleasant and above the Lumberville wing dam and flows parallel to the river to a point above Trenton. Boyer at 2833-34. The net diversion via this canal is presently limited by physical restriction to 60 MGD or 90 cfs. The authorized maximum diversion from the Delaware River is 100 MGD or 150 cfs. Boyer at Tr. 2834. Additional water flowing into the Canal is largely returned to the Delaware through overflow points at stream crossings and thus is included in flows at Trenton. Boyer at Tr. 2835-36, 2858-63, 2869.

59. Applicant's method of constructing the rating curve involved techniques commonly used for such work. Phillippe at Tr. 3698-3700.

60. One point on the Applicant's rating curve is the result of actual flow measurements made by the United States Geological Survey

(USGS) on September 12, 1981. On that date the flow at Lumberville was measured at 3340 and the flow into the Delaware and Raritan Canal was measured at 300 cfs, giving a total flow of 3640 cfs at Point Pleasant. Bourquard at Tr. 2261-2265. The river elevation at the Point Pleasant intake was simultaneously measured and was found to be 71.27 feet. Boyer at Tr. 2336. The Applicant's witnesses indicated that this confirmed the accuracy of the rating curve. Bourquard at Tr. 2269.

61. A witness for the Applicant testified that at flows of approximately 4500 cfs, the elevation shown by the rating curve should be accurate to within 0.1 foot. Bourquard at Tr. 2305.

62. The Staff and the Applicant believed that the flow measurement of 3000 cfs on November 7, 1980 was accurate to within 100 cfs. Bourquard at Tr. 2273; Wescott at Tr. 3931. Del-Aware's hydrological witness indicated that the flow on November 7, 1980 was, if anything, less than 3000 cfs. Phillippe at Tr. 3769.

63. Both the Applicant and the Staff indicated that the July 23, 1981 flow figure of 4500 cfs was less precise. Bourquard at Tr. 2272; Wescott at Tr. 3920-21.

H. Bypass Velocity at Low Flow

64. Velocity measurements taken at low flows such as 3000 cfs may be used to estimate velocities which may occur at lower flows such as

2500 cfs. Provided that there is no significant difference in water level the velocity distribution should be nearly identical, that is, the ratio of screen bypass velocity to average cross-sectional velocity at 2500 cfs is the same as it is at 3000 cfs. Wescott at Tr. 3609-3610.

65. The Applicant's velocity measurements define the cross-sectional velocity distribution in the river at low flows and are adequate to draw conclusions as to the likely velocity distribution past the screens during periods of ecological concern. Wescott Testimony, ff. Tr. 3490, at 4.

66. Using the minimum velocity measured at a screen location (west intake - 7 foot level) at 3000 cfs, the calculated ratio of screen bypass velocity to average cross-sectional velocity was 1.4. Assuming a constant bypass/average cross-sectional velocity of 1.4, the bypass velocity at a river flow of 2500 cfs was calculated to be 0.8 fps. Wescott at Tr. 3609-10; Boyer at Tr. 1350-51.

I. Occurrence of Low Flows

67. Historically, flows at the Trenton gage have exceeded 2900 cfs 90 percent of the time for the period 1913 to 1980. During this period, many presently existing storage projects or reservoirs which can increase river flow were not in operation. Since the drought of the 1960's there has been an addition of approximately 135 billion gallons

of storage on the Delaware River, i.e., an increase of 56 percent. Boyer at Tr. 1360-62, 2575-77.

68. During the months of April, May and June when the early life stages of fish are most likely to occur, daily flow records over the last 20 years show that flows below 3000 cfs in the Delaware River at Trenton have occurred about 1 percent of the time. Brundage at Tr. 3003; Masnik at Tr. 3558.

69. Historically, over the last twenty years flows at Trenton during April and May have never gone below 3,000 cfs. McCoy at Tr. 3212. See also Phillippe Testimony, ff. Tr. 3658, at 4. Four times in the past 23 years, the minimum daily flow for June has been 3000 cfs or below. This indicates that on at least one day during the month, the flow has been that low. McCoy at Tr. 3214-15. Del-Aware presented data, however, that over the past 17 years flows have been less than 3050 cfs only 2.9% of the time in June. Phillippe Testimony at 4.

70. Flows have been somewhat lower in July when juvenile fish may be present. During twelve of the last thirty years the minimum daily flow for July has been below 3000 cfs. McCoy at Tr. 3345. Over 17 years, flows during July were below 3050 cfs 19.4% of the time. Phillippe Testimony, ff. Tr. 3658, at 4.

71. According to the Executive Director of the Delaware River Basin Commission (DRBC), the lowest anticipated flow at Trenton is 2500 cfs. This estimate is based on current hydrology and existing upstream storage. Hansler at Tr. 1261. It does not consider storage from the proposed Merrill Creek reservoir. Id. at Tr. 1272-74.

72. The DRBC has conditioned the withdrawal rights such that water used for Limerick can be withdrawn from the Delaware River so long as the river's flow exceeds 3000 cfs at Trenton unless PECo and other utilities provide offstream storage within the basin. In that case PECo could withdraw up to the amount they release from a storage system, up to their total allocation (46 MGD for Limerick), regardless of the flow in the Delaware. Hansler at Tr. 1227.

J. Orientation of the Intake Screens Relative to the Flow

73. Screen slot orientation is a factor to consider in determining the efficacy of the screens. Brundage at Tr. 2933-34. However, the orientation is not a major protective feature since screens of this type have been shown effective at a variety of orientations to the flow. Harmon at Tr. 2814; Masnik at Tr. 3986.

74. The screen slots of the Point Pleasant intake screen would be roughly perpendicular to the flow. Harmon at Tr. 2807. Brundage at Tr. 2969; McCoy at Tr. 3306.

K. Impact on Shortnose Sturgeon

75. The shortnose sturgeon is on the list of endangered species maintained by the Secretary of the Interior pursuant to the Endangered Species Act, as amended, 16 U.S.C. §§ 1531-43 (1976 & Supp); 50 C.F.R. § 17.11 (1981). The National Marine Fisheries Service, has prepared, pursuant to the requirements of that act, a Biological Opinion finding that operation of the Point Pleasant Pumping Station is not likely to jeopardize the existence of shortnose sturgeon in the Delaware River. National Marine Fisheries Service, Endangered Species Act: Section 7 Consultation - Biological Opinion.

76. Shortnose sturgeon exist in the Delaware River. However, no shortnose sturgeon have been found at or above Point Pleasant. Applicant's Testimony, ff. Tr. 949, at 7, 9.

77. Lambertville, New Jersey, at river mile 149, is the farthest upstream location where the taking of shortnose sturgeon has been recorded. Two sturgeon were taken there in 1975 and eleven were taken in 1981. Lambertville is eight miles downstream from Point Pleasant. Applicant's Testimony, ff. Tr. 949, at 10; Masnik Testimony, ff. Tr. 3504, at 7; Harmon at Tr. 2681-82.

78. State and federal agencies have sampled for fish for a number of years in the stretch of the river in which the intake will be

located. No shortnose sturgeon have ever been found there. Harmon at Tr. 2681.

79. Harold M. Brundage III, a fisheries biologist who has studied shortnose sturgeon in the Delaware River estuary since 1978, conducted a sampling program for shortnose sturgeon in the vicinity of the Point Pleasant intake during the months of November, December, February and March of 1981-82. He also found no sturgeon. While Brundage's study was not conducted during the sturgeon's spawning season, sturgeon migrate upriver to spawn during March, April and early May. Therefore, the failure to find Sturgeon at Point Pleasant in late March is some indication that they do not spawn there. Harmon at Tr. 2427; Brundage at Tr. 2924, 2989-90, 3005-06; Applicant's Testimony, ff. Tr. 949, at 10-11; Professional Qualifications of Harold M. Brundage, III, following Tr. 2965.

80. Shortnose sturgeon are a comparatively difficult fish for which to sample. McCoy at Tr. 3068-69; Miller at Tr. 3071. Brundage used the appropriate methods in conducting his sampling program although his program was somewhat limited in the number of locations and frequency of samples. McCoy at Tr. 3070-71.

81. Healthy adult shortnose sturgeon, if present, would be protected from impingement by their size, swimming ability, and preference for staying at the bottom of the river. Masnik Testimony,

ff. Tr. 3504, at 8-9; Masnik at Tr. 3981; Emery at Tr. 1871-72; Harmon at Tr. 2888; Brundage at Tr. 2959-60.

82. Sturgeon spawn over rubble, cobble or gravel bottoms in high velocity fresh water in the range of 9°C to 12°C. They spawn in or above the tidal reaches of the river. A single sturgeon will lay approximately 140,000 eggs. The actual spawning occurs in the channel, near the river bottom. Applicant's Testimony, ff. Tr. 949, at 10; Emery at Tr. 1803, 1814; Brundage at Tr. 2924, 2928, 2991, 3030-31.

83. Sturgeon in the Delaware River probably spawn in the tidal waters immediately below the fall line at Trenton or in the non-tidal river immediately upstream of the falls. Brundage at Tr. 2984.

84. Although the Point Pleasant area has a river bottom which would be suitable for use by spawning sturgeon, there is no evidence to indicate Sturgeon actually spawn there. Masnik Testimony, ff. Tr. 3504, at 6-7; Brundage at Tr. 2928.

85. Shortnose sturgeon eggs are 3.0 to 3.2 mm in diameter. They are dense and demersal, and accordingly sink rapidly out of the water column. It is unlikely that they would drift far with the current before sinking to the bottom. The eggs are adhesive and become affixed to the substrate on which they land. Applicant's Testimony, ff. Tr. 949, at 11; Masnik Testimony, ff. Tr. 3504, at 7; Emery at Tr. 1798-99; Brundage at Tr. 2969.

86. If shortnose sturgeon were to spawn at Point Pleasant, it is highly unlikely that sturgeon eggs would be entrained or impinged in significant numbers. The eggs would be in the water column only a short time before adhering to the bottom. Therefore, there would be only a short time during which they could come into contact with the intake. In addition, the eggs are larger than the slots in the intake. While it would be possible for them to be crushed and extruded, work by Hanson has shown that it is more likely that they would roll along the intake surface and eventually off the intake. Applicant's Testimony, ff. Tr. 949, at 11; Masnik Testimony, ff. Tr. 3504, at 6-7; Emery at Tr. 1799-1801; Harmon at Tr. 2845; Brundage at Tr. 2969, 3028; Masnik at Tr. 3981.

87. Shortnose sturgeon larvae are very benthicly oriented during their first days of life. Until they are sixteen days old they occupy interstitial spaces, essentially without moving off the bottom. After sixteen days there may be some movement off the bottom, but some benthic orientation may continue for up to 43 days. Applicant's Testimony, ff. Tr. 949, at 11; Masnik Testimony ff. Tr. 3504, at 7-8; Kaufmann at Tr. 1869; Harmon at Tr. 2516-17; Brundage at Tr. 2945-46, 2988; Masnik at Tr. 3592-96.

88. There is some evidence that shortnose sturgeon larvae which are less than 20.5 mm in total length (a size reached at approximately 18.5 days of age) may be susceptible to entrainment if they contact the intake screens. Masnik Testimony, ff. Tr. 3504, at 7; Brundage at Tr. 2942-43.

89. Given their strong bottom orientation, there is little likelihood that if larvae small enough to become entrained are present, they would encounter even the lower portion of the intake screens, located two feet off the bottom. Applicant's Testimony, ff. Tr. 949, at 11-12; Masnik Testimony, ff. Tr. 3504, at 8; Harmon at Tr. 2515-17. One of Del-Aware's witnesses stated that he didn't think that any sturgeon larvae would be entrained. Emery at Tr. 1870.

90. Shortnose sturgeon larvae show strong swimming ability even before they begin to move off the bottom. A 15.5 mm larva can sustain burst swimming for approximately 38.1 cm. A 16.5 mm larva has a burst speed of approximately 14.7 cm/sec (about 0.6 fps). Brundage at Tr. 2988, 3016.

91. Larger larvae, which might venture further up in the water column where they might encounter the intake, would be protected from impingement by their strong swimming ability and the hydrodynamics of the intake. Brundage at Tr. 2972, 3023; Masnik at Tr. 3981-82.

92. Charles Emery, an employee of the Pennsylvania Fish Commission, expressed concern that shortnose sturgeon might be susceptible to impingement within the first 25 days of life. Mr. Emery

apparently based his conclusion on the size of the larvae and did not take into account the benthic orientation and swimming ability of the larvae. Emery at Tr. 1870-71.

93. Given the design of the intake, if shortnose sturgeon larvae were present in the vicinity of the Point Pleasant intake, the effect upon them would be "infinitesimally small" (Harmon at Tr. 2845), there would be "virtually no impingement" (Brundage at Tr. 2972), and both entrainment and impingement would be "highly unlikely". Masnik at Tr. 3981.

94. It is highly unlikely that healthy juvenile sturgeon, which are both larger and stronger swimmers than larvae, would be impinged on the Point Pleasant intake. Masnik Testimony, ff. Tr. 3504, at 8; Masnik at Tr. 3981; Brundage at Tr. 2960.

L. Impact on American Shad

95. American Shad spawn in the Delaware River and pass through the Point Pleasant area during their migration. However, all the witnesses were in agreement that the intake would not cause impingement or entrainment of adult shad. Applicant's Testimony, ff. Tr. 949, at 8; Masnik Testimony, ff. Tr. 3504, at 22-23; Kaufmann at Tr. 1792, 1855, 1883, 1950; Miller at Tr. 3244.

96. Juvenile Shad pass through the Point Pleasant area during their outmigration and use the Lumberville pool, which extends from the Lumberville wing dam to a riffle near the mouth of the Tohickon Creek, as a nursery area. Applicant's Testimony, ff. Tr. 949, at 7.

97. Several witnesses gave differing ages and sizes which they felt indicated the start of the juvenile stage i.e., that the larvae had undergone transformation and become juvenile fish. See Masnik, Testimony, ff. Tr. 3504, at 13; Emery at Tr. 2109-10; Miller at Tr. 3169, 3219, 3239-42. These differences may not indicate disagreements, but could reflect a lack of precision in defining the beginning of the juvenile stage. For the purposes of this opinion, however, we adopt the description given by Mr. Miller, a fishery biologist who has worked extensively with American Shad in the Delaware River, that transformation occurs at approximately 28-30 mm in length. This would be approximately 30 days after hatching. Direct testimony of Joseph P. Miller on behalf of Del-Aware, Inc., ff. Tr. 3046, at 1; Miller at Tr. 3168-69.

98. There would be virtually no possibility of entrainment of juvenile shad because of their size and their stage of development. Miller at Tr. 3168-69, 3241-42.

99. Healthy juvenile shad should not be impinged by the intake. Even Del-Aware's witnesses testified that, for shad larger than 25 mm,

an intake velocity of 0.5 feet per second should not cause impingement. Masnik Testimony, ff. Tr. 3504, at 22-23; Emery at Tr. 1963-64, 2066.

100. Del-Aware's witnesses were concerned that shad 25-40 mm in total length could be drawn to the intake and escape only after making contact with the screen surface. Concern was expressed that this could kill the fish by causing them to lose their scales. Emery at Tr. 1962-63, 1977, 2066. Descaling could also occur if the shad were to brush against a rock (Emery at Tr. 2143), so the problem is not unique to intakes. Moreover, the witnesses did not indicate that the problem was worse for the proposed location than for other locations. Kaufmann at Tr. 2143.

101. The small zone of influence of this intake compared to the cross-section of the river at Point Pleasant (See finding 27) minimizes the likelihood that descaling of juveniles as a result of contact with the intake would be a problem. The same witnesses who expressed concern that juveniles might be pulled to the intake and suffer descaling problems indicated that the zone of influence of the intake was sufficiently small that their concern was essentially limited to the area within two inches of the screens insofar as eggs and larvae were concerned. Kaufmann at Tr. 1882. Since juveniles have much greater mobility than eggs and larvae (Miller at Tr. 3168-70), the area in which they could be impacted should be even smaller.

102. Historically, American shad spawned in the Delaware River from Philadelphia to the headwaters of the river in New York. Testimony of

Michael Kaufmann, ff. Tr. 1736, at 6; Miller Testimony, ff. Tr. 3046, at 1-2. During the twentieth century the spawning range in the Delaware declined, perhaps due to pollution causing low dissolved oxygen levels in the estuary beginning in late April or May each year. Thus, in the 1970's, shad spawning in the Delaware occurred only upstream of the Delaware Water Gap. Miller Testimony at 2-3; Masnik Testimony, ff. Tr. 3504, at 12; Kaufmann Testimony, at 5-8. In 1980 and 1981, however, the low dissolved oxygen levels did not occur until later in the spring. Kaufmann at Tr. 2103-04. During these years there was evidence of shad spawning downriver of the Delaware Water Gap. There is evidence that shad may have been spawning between Lambertville and Easton, much closer to Point Pleasant than where spawning occurred during the 1970's. Specifically, "running ripe" shad have been observed at Lambertville, 8 miles south of Point Pleasant. This condition occurs in shad only during or shortly prior to spawning. Kaufmann Testimony at 9; Miller Testimony at 3-4; Emery at Tr. 1762-63, 1780-81, 2002; Kaufmann at Tr. 1942-43.

103. Several months before the hearing, the Applicant collected samples of what could have been shad eggs at Point Pleasant. By the time of the hearing, the Applicant had not yet analyzed the samples to ascertain if they did, in fact, contain shad eggs. Harmon at Tr. 2363-64, 2405.

104. There was conflicting testimony as to whether spawning has occurred at Point Pleasant in the past two years. Applicant's Testimony,

ff. Tr. 949, at 7; Masnik Testimony, ff. Tr. 3504, at 12; Kaufmann at Tr. 1785, 1976, 2101-03; Emery at Tr. 1785; Miller at Tr. 3049, 3129-30, 3355. Point Pleasant is within the stretch of the river in which spawning historically occurred, and spawning could occur there in the future if it is not occurring at the present time. Kaufmann Testimony, ff. Tr. 1736, at 9-10; Miller at Tr. 3049. For purposes of evaluating the intake's potential impact on shad, the Applicant assumed that spawning will occur at Point Pleasant. Harmon at Tr. 2405, 2408.

105. Shad normally spawn in the downstream 1/3 of a pool. Thus, spawning probably would not occur in the immediate vicinity of the intake. Kaufmann at Tr. 1943, 1961. Rather, concerns were raised that eggs and larvae spawned in the pool immediately upstream from the Lumberville pool in which the intake is located would drift into the Lumberville pool and be impinged or entrained. Kaufmann at Tr. 1961.

106. The Applicant's and the Staff's witnesses gave slightly different ranges for the size of shad eggs. The Applicant presented testimony that shad eggs range from 1.1 to 3.8 mm in diameter. Applicant's Testimony, ff. Tr. 949, at 8. A Staff witness testified that the eggs ranged from 2.1 to 3.8 mm in diameter. Masnik Testimony, ff. Tr. 3504, at 16.

107. Shad eggs have a mean diameter of 2.83 mm. Applicant's Testimony, ff. Tr. 949, at 8. Thus, most of the eggs would be larger

than the intake slots. In addition, the eggs water harden within a few minutes of spawning if they have been fertilized. Miller at Tr. 3153, 3348. However, even a water hardened egg is relatively fragile and may be crushed and pulled through the intake or may be damaged by being pulled against it. Emery at Tr. 1768; Miller at Tr. 3153-58. Witnesses for all the parties agreed that eggs which were sufficiently close to the intake could be entrained. Masnik Testimony, ff. Tr. 3504, at 14; Kaufmann at Tr. 1950; Harmon at Tr. 2398-9; Miller at Tr. 3153-3195.

108. Shad eggs are demersal. They rapidly sink to the bottom within approximately 5 to 35 meters from the point of spawning although they may be carried further. Masnik Testimony, ff. Tr. 3504, at 12, 16; Emery at Tr. 1761-62, 2136; Miller at Tr. 3204, 3296. During the period of sinking, they could be exposed to the intake.

109. A single shad female lays an estimated 100,000 to 500,000 eggs. Masnik at Tr. 3564. See also, Emery at Tr. 1760; Miller at Tr. 3157. Less than one percent of these eggs would hatch even if they were not affected by the intake. Emery at Tr. 1761; Masnik at Tr. 3560.

110. One witness indicated that eggs which spent a longer time in the water column before sinking to the bottom, would be less likely to survive. Since a longer time spent in the water column would increase the time of potential interaction with the intake, the eggs most likely to be impacted by the intake would likely be eggs which would not have produced larvae even if they were not so impacted. Masnik at Tr. 4006-07.

111. Shad larvae are 5.7 to 10.0 mm in length when hatched. Larvae range in size from approximately 7.0 to 30.0 mm. They reach 20.0 mm at approximately 17 or 18 days of age. Masnik Testimony, ff. Tr. 3504, at 13, 17; Miller at Tr. 3218-19; Emery at Tr. 2109.

112. Shad larvae display a behavior pattern whereby they rise to the water surface and then sink to the bottom. They then rise again to the surface and repeat the pattern. Masnik Testimony, ff. Tr. 3504, at 13, 20; Miller at Tr. 3052-53.

113. Larvae can be found anywhere in the water column. Miller at Tr. 3298. It is reasonable to assume that larvae are distributed uniformly throughout the water passing an intake site. Harmon at Tr. 2897.

114. Larvae less than 20 to 25 mm in length are basically at the mercy of the current. Emery at Tr. 2109; Harmon at Tr. 2423; Miller at Tr. 3052-53, 3204. While in the larval stage, a shad may be carried 40 to 50 miles downstream. Miller at Tr. 3221-22.

115. All larvae, even those just hatched, have some mobility and some avoidance capability. Miller at Tr. 3169-70, 3223, 3331; Harmon at Tr. 2423-25, 2553-54. Although the ability to avoid the intake may be limited in small larvae (Miller at Tr. 3331), other species which, like

shad, are members of the alosa genus have shown resistance to intakes when 10 to 15 mm in length. Applicant's Testimony, ff. Tr. 949, at 9; Harmon at Tr. 2421-22. In addition, studies on species other than shad have shown that larvae are entrained by intakes with wedge-wire screens at a lesser rate than would be expected on the basis of physical exclusion alone. Masnik Testimony, ff. Tr. 3504, at 17-18.

116. Shad larvae which are 20 mm or less in total length and pass sufficiently close to the intake screens will be susceptible to entrainment. Miller Testimony, ff. Tr. 3046, at 4; Masnik Testimony, ff. Tr. 3504, at 14, 17; Miller at 2220; Harmon at 2853.

117. Larger larvae (20-30 mm) may be subject to impingement or bruising if they pass sufficiently close to the intake screens. Masnik Testimony, ff. Tr. 3504, at 21; Harmon at Tr. 2416; Miller at Tr. 3220, 3241-42.

118. Assuming that larvae are distributed uniformly in the water passing by the intake site, and assuming no physical exclusion or avoidance behavior, at worst the percentage of larvae lost will equal the percentage of the total flow which is withdrawn. Masnik Testimony, ff. Tr. 3504, at 15; Emery at Tr. 2063-65; Harmon at Tr. 2397-98.

119. Shad spawn in April, May, and early June. Emery at Tr. 2061-62. The larvae hatch within two weeks after the eggs are

fertilized (Emery at Tr. 2108), and transformation to the juvenile stage occurs about a month later (see Finding 97). Eggs and larvae could be in the Point Pleasant vicinity during the months of April, May, June, and July.

120. For average flow conditions, the percentage of water volume removed at the maximal pumping rate, and thus, the percentage of larvae impacted (assuming uniform distribution, no avoidance, and no physical exclusion) would be less than two percent of those passing the site. Masnik Testimony, ff. Tr. 3504, at 15.

121. The Lumberville pool and the Point Pleasant vicinity have no unique value as a spawning site for shad. Masnik at Tr. 3577. There are hundreds of other pools in the Delaware River which are spawning grounds for shad. Kaufmann at Tr. 1943-44. See Finding 102.

122. One of Del-Aware's witnesses expressed concern that the loss of any shad eggs or larvae would have a detrimental effect on the ability of shad to expand their total historic spawning range. Miller at Tr. 3201, 3274, 3330.

123. A Staff witness testified that the intake "will not jeopardize the continued existence or anticipated future gains in population" of American shad in the Delaware River. Masnik Testimony, ff. Tr. 3504, at

11, 21-23. See also Masnik at 3550-52, 3561, 3987-3993. The Applicant's biological witness agreed. Harmon at Tr. 2846, 2885.

124. In view of the insignificant effect the intake will have on American shad and shortnose sturgeon populations, there is no significant benefit to be gained from locating the intake further from the west bank of the river. Masnik at Tr. 3548-49, 4032; Brundage at Tr. 2959.

M. Impacts on Recreation

125. Some of Del-Aware's witnesses expressed concern that the intake could be a danger to boaters, rafters, and tubers (i.e., people floating down the river sitting in or holding onto an innertube). Emery Testimony, ff. Tr. 1736, at 14;[8] Direct Testimony of Stanley Plevyak, ff. Tr. 1930, at 2; Plevyak at Tr. 2021.

126. Although the witnesses testified that there are rocks in the river and that fishing lures and hooks have been lost on items already in the river (Emery at Tr. 1814; Plevyak at Tr. 1967-70), they could not detail any incidents of the type about which they were concerned, with

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8 Although in the bound-in testimony this is indicated to be Michael Kaufmann's testimony, Mr. Emery indicated that actually his testimony began on page fourteen of the prefiled material. Tr. 1736.

regard to the intake. Emery at Tr. 1816, 1888; Kaufmann at Tr. 1887-88; Plevyak at Tr. 2013.

127. The intake would be covered by approximately four feet of water at flows of 3,000 cfs. (See Finding 15). Tubers sometimes float through areas where the water is only a foot to 18 inches deep. Kaufmann at Tr. 1887; Plevyak at Tr. 2012. These areas may contain rocks. Kaufmann at Tr. 1887.

128. Del-Aware presented evidence that Point Pleasant is one of the six best shore fishing spots on the Pennsylvania side of the Delaware between Trenton and Easton and the second best spot for shore fishing for shad in that area. Kaufmann Testimony, following Tr. 1736, at 10-11; Plevyak at Tr. 1951.

129. Shad migrating upriver to spawn are believed to travel in a relatively narrow section of the river where they find an appropriate velocity. At Point Pleasant this migratory path is sufficiently close to shore that fishermen can cast into it from the Pennsylvania shore. Kaufmann Testimony, ff. Tr. 1736, at 13-14; Kaufmann at Tr. 1788, 1793.

130. Although shad travel within one foot of the bottom during their migration (Kaufmann at Tr. 1862) and the intake screens will be two feet above the bottom (see Finding 15), the shad, which are "spooky" (Miller at Tr. 3245, 3348-49), might change their migratory path if they were to encounter the intake and move beyond the range of fishermen

casting from the Pennsylvania shore. Kaufmann Testimony, ff. Tr. 1736, at 13-14; Kaufmann at 1792, 1951.

131. The witnesses did not indicate whether the intake, as proposed, would be in the migratory path of the shad. Thus, it could be that a different location for the intake would have a more serious impact on shad fishing. Kaufmann at Tr. 1957. Although a shoreline location would be least likely to divert migrating shad, the witnesses did not favor it because of its other drawbacks. Kaufmann at Tr. 1956-58.

132. If the intake were located so that it caused diversion of migrating shad, the witnesses were not certain whether the fish would move towards Pennsylvania and the fishermen or towards New Jersey and away from the fishermen. Kaufmann at Tr. 1793-4, 2129-30.

N. Noise from Intake Operation

133. Contention V-16a states:

> Noise effects and constant dredging maintenance connected with operations of the intake and its associated pump station will adversely affect the peace and tranquility of the Point Pleasant proposed historic district.

See SPCO, LBP-82-43A, 15 NRC at 1479.

134. The Point Pleasant Historic District has been declared eligible for listing on the National Register of Historic Places by the keeper of the National Register. NRC Staff Testimony of

Brian J. Richter on Limerick Contention V-16a, ff. Tr. 1118, at 3 n.1. The District is significant because it preserves the atmosphere and environment of a canal town in the nineteenth century. Direct Testimony of Professor Pierce Lewis at 2-4;[9] Richter Testimony, at attachment 1.

135. Noises which would be out of character with a property or would alter its setting may constitute adverse effects on National Register sites which must be considered by federal agencies. Richter, Testimony, ff. Tr. 1118, at 4; 36 C.F.R. § 800.3(b).

136. Although the Pennsylvania State Historic Preservation Officer and the Federal Advisory Council on Historic Preservation, which are responsible for providing expert advice on the impacts of federally licensed projects, have been consulted about the Point Pleasant diversion project, neither has identified noise from the intake and pumping station as an adverse impact on the proposed historical district. Richter Testimony, ff. Tr. 1118, at 4-5.

137. A site noise survey was done in 1981 to determine ambient noise levels. Applicant's Testimony, ff. Tr. 949, at 13. The ambient

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9 Professor Lewis' Testimony is bound into the record in an earlier form following Tr. 4036. By agreement of the parties (Tr. 3950-51), Professor Lewis' testimony was submitted with minor changes on November 4, 1982, accompanied by his affidavit that he adopted it as his testimony in the proceeding.

noise level was measured at a site 30 feet from the southern property line of the pumping station and 100 feet east of the road. Moiseev at Tr. 1058-59. Because ambient noise levels do not generally vary much over a short distance, this may reasonably be considered representative of the ambient noise level for the entire pumphouse property. Moiseev at Tr. 1059.

138. Ambient noise levels are measured by excluding transient noise sources such as the sound of a car passing nearby. Moiseev at Tr. 1041-42. To get a low background reading, one generally takes the lowest noise level measured over a fifteen minute period. Policastro at Tr. 1143, 1145.

139. The Applicant's data on ambient noise were collected during October. Moiseev at Tr. 1069. The Applicant measured low noise levels for a full day and measured daytime octave band sound pressure levels. Applicant's Testimony, ff. Tr. 949, at 13; NRC Staff Testimony of Anthony Policastro in Response to Contention V-16a, ff. Tr. 1118, at Ex. 2. It is standard practice to measure ambient noise levels between midnight and 4:00 a.m. Policastro at Tr. 1147. Applicant does not have nighttime ambient octave band sound pressure levels, but one would expect nighttime noise levels to be somewhat lower than those during the day. Policastro at Tr. 1143-1146. The Staff's expert on noise estimated that nighttime levels would be three decibels (dB) below the measured daytime levels. Policastro at Tr. 1175.

140. The Applicant evaluated the noise impact of the pumping station and the intake by comparing it to an overall A-weighted ambient sound level which is exceeded 90 percent of the time (L_{90}). Moiseev at Tr. 999, 1036-37; Policastro at Tr. 1141.

141. An A-weighted noise level is one which is measured on a filtered instrument system which biases the meter to respond as would an average human ear. Thus, it is less sensitive to noises at low or high frequencies than it is to frequencies in the middle range. Applicant's Testimony, ff. Tr. 949, at n. 14.

142. The L_{90} sound level is not an appropriate figure to use for planning purposes because, being A-weighted, it deemphasizes the lower frequency range. That lower frequency range is the area in which transformer noise may be annoying. Policastro at Tr. 1141-42.

143. To determine whether a noise will be annoying to people, it should be compared with the masking level of the ambient noise at each tone at which it has a component. The masking level is calculated from the sound level at a particular tone and at nearby frequencies (within about 20 hertz). Policastro at Tr. 1129-31.

144. Generally, people are able to perceive a noise that is 3 dB above the masking level at any particular tone. People begin to complain of acoustical discomfort or annoyance when tones are 5 dB above

the masking levels. Policastro at Tr. 1157-58, 1181. The 5 dB level for annoyance apparently applies at any frequency. Policastro at Tr. 1180.

145. The pumphouse would contain four vertical multistage centrifugal pumps driven by electric motors. The fourth pump is proposed to be installed between the years 1990 and 2000. Applicant's Testimony, ff. Tr. 949, at 14. The technical specifications call for pumps to have a sound level rating of no more than 86 dB as measured by IEEE Standard 85. Bourquard at Tr. 987-88.

146. The other noise sources within the pumphouse would be ventilating equipment and small air compressors. The noise they contribute would be about 10 dB less than that of the pumps. Boyer at Tr. 1062; Moiseev at Tr. 1062-63.

147. The plans no longer call for emergency generators, and the Applicant's witness indicated that no such machinery would be added in the future. Boyer at Tr. 1021-23.

148. The pumphouse walls would be insulated. The floors would be concrete. The roof would be insulated concrete plank. There would be no windows. Sound attenuating designs would be used for all ventilating systems. Applicant's Testimony, ff. Tr. 949, at 14-15.

149. The Staff's witness on noise had not ascertained at the time he testified what the sound specifications were for the doors of the pumphouse or exactly where the air intake would be located. Policastro at Tr. 1122-23. He did not seem to consider this lack of information to affect seriously his ability to draw conclusions, and he testified that it was well within state-of-the-art technology to remedy any problems which might exist concerning noise transmission to the outside of the building by these pathways. Policastro at Tr. 1166-69.

150. The pumphouse structure would attenuate the noise generated inside it sufficiently that there would be very little noise outside it and what noise there is would be well below the ambient sound level. Policastro at 1121-22, 1124-25.

151. Further noise attenuation would occur at greater distances from the noise source (e.g., the pump). The 86 dB rating for the pumps is at a distance of one meter. Moiseev at Tr. 1009. The rule of thumb is that noise attenuates 6 dB with doubling of the distance from the source. Moiseev at Tr. 1005.

152. As a result of attenuation due to the pumphouse structure and distance, the noise from equipment inside the pumphouse would be at or below ambient noise levels at the closest site property line. Applicant's Testimony, ff. Tr. 949, at 15; Moiseev at Tr. 979-80, 984-86, 1001, 1004, and 1026.

153. There would be two transformers outside the building. Applicant's Testimony, ff. Tr. 949, at 14-15. The transformers would be immediately adjacent to the side of the building facing the river (the east side). They would be approximately 100 feet from the Delaware Canal. Boyer at 990. The transformers would be 15 to 20 feet apart and there would be a firewall between them. Boyer at 990-91.

154. Although the specifications had not yet been changed to reflect it, the Applicant's Senior Vice President - Nuclear Power testified that a decision had been made to use low noise level transformers. These transformers are rated at 57 dB using A-weighted measurements, or 10 dB below standard transformers. The Applicant is committed to modifying the specifications to reflect that these "quieted" transformers would be required. Boyer at Tr. 1030-31; Moiseev at Tr. 1030.

155. Transformers produce a steady state noise consisting of noise at discrete frequencies. The noise has a fundamental frequency at 120 hertz (Hz) and harmonic frequencies at multiples thereof. Moiseev at Tr. 1066, 1068. These discrete frequencies may render the noise bothersome even though it is only a low pitched hum. Moiseev at Tr. 1088-89. The discrete frequencies also mean that transformer noise may change the character of the noise in an area even if the overall background noise level is not exceeded. Policastro at Tr. 1129-1131.

156. To determine whether the transformer noise would be annoying to people, the noise level must be compared to the masking level at each of the discrete frequencies at which the transformer has a fundamental frequency or harmonic frequency (i.e., 120, 240, 360, and 480 Hz). This has not been done. Policastro at Tr. 1126, 1130-31.

157. Although the Staff's witness had not received information on the final design of the transformers so that he could make this comparison (Policastro at Tr. 1125-26), he believed, on the basis of the information that he did have, that the transformers would cause audible noise beyond the pumphouse property site at those tones at which it has fundamentals. Policastro at Tr. 1132.

158. The Staff's witness was concerned that the transformers would produce objectionable noise at nearby residences which he referred to as Residences 1 and 4. Testimony of Anthony Policastro, ff. Tr. 1118, at 5; Policastro at Tr. 1138-39. Residence 4 would be closer to the transformers than would Residence 1. Policastro Testimony at Ex. 1.

159. Technology exists (e.g. sound barriers) which could be used to eliminate any noise off the pumphouse site which would be annoying. Moiseev at Tr. 1046, 1055; Policastro at Tr. 1132-33, 1153, 1158-59. If further quieting is necessary, this technology may be utilized at the Point Pleasant pumphouse site. Cost, however, weighs against requiring use of such technology unless it proves necessary to further reduce noise. Moiseev at Tr. 1046-47; Bourquard at Tr. 1047; Policastro at Tr. 1132.

160. The Applicant estimated that sound barriers would cost approximately $35,000 to $40,000 to install. Bourquard at Tr. 1048.

O. Impacts from Dredging and Maintenance

161. Although Contention V-16a alleges adverse impacts from dredging maintenance, no evidence was presented that any maintenance dredging would be required once construction is complete. Rather, the evidence indicated that the riprap placed beneath the intake should aid in keeping the bottom there swept clean. Bourquard at Tr. 2662. Essentially, the flow velocity should be sufficient to prevent material from accumulating under the intake. Applicant's Testimony, ff. Tr. 949, at 15; Bourquard at Tr. 2823.

162. Comparison of ground surface elevation measurements made in connection with the taking of core borings at Point Pleasant in 1981 with contours established by a survey made fourteen years earlier indicate that the bottom grade had not changed significantly as a result of material deposited during that period. Applicant's Testimony, ff. Tr. 949, at 15-16; Bourquard at Tr. 2176-77, 2607-09.

163. Del-Aware's witnesses were also concerned that the intake would be damaged by ice and debris in the river being swept against it, and that this would necessitate complicated and noisy repair work.

Testimony of Richard McNutt, ff. Tr. 3382, at 2, 4, 5, 8; Phillippe at Tr. 3793-95.

164. Del-Aware's chief witness on the question of damage to the intake testified that ice blocks and debris floating down the river occurred after rains. McNutt at Tr. 3401, 3403-04, 3409-10, 3442-43. He testified that he was concerned with a six inch flow over the bar of rocks at the mouth of Tohickon Creek at the time ice blocks would exist. McNutt at Tr. 3435. He also discussed a 20 foot by 20 foot block of ice going over the Lumberville wing dam. McNutt at Tr. 3449. This confirms the view that ice and debris would be floating in the river primarily when there are relatively high flows covering the intake. See also Applicant's Testimony, ff. Tr. 949, at 16; Boyer at 2537.

165. Additional protection from damage by ice or debris would be provided by three 12-inch diameter vertical steel guard posts at the upstream end of the intake structure. Applicant's Testimony, ff. Tr. 949, at 16; Boyer at Tr. 2541.

166. Should debris accumulate against the intake structure, it would be removed from a boat or by a diver. Applicant's Testimony, ff. Tr. 949, at 16. The Applicant anticipates the need to clear away debris perhaps once a year. Boyer at Tr. 2538.

167. If the intake were damaged, repair work could be performed under water. Boyer at Tr. 2546; McNutt at Tr. 3439-40.

168. If necessary, an intake screen section could be removed for repair and replaced. Divers could accomplish this without difficulty. Boyer at Tr. 2539-40. This might require a barge in the river and, perhaps, a crane. McNutt at Tr. 3446-47.

III. CONCLUSIONS OF LAW

Based upon the foregoing Opinion and Findings of Fact which are supported by reliable, probative and substantial evidence as required by the Administrative Procedure Act and the Commission's Rules of Practice, and upon consideration of the entire evidentiary record in this proceeding, the Board reaches the following conclusions pursuant to 10 C.F.R. § 2.760a:

1. With respect to Contentions V-15 and V-16a (in part), there will be no adverse impact on American shad, shortnose sturgeon, boating, or recreation which would render invalid the favorable cost-benefit analysis from the construction permit stage, and there will be no impacts requiring mitigation measures for compliance with Section 102 of the National Environmental Policy Act of 1969, 42 U.S.C. § 4332 (1976).

2. With respect to Contention V-16a, the Board is imposing a condition in its Order, infra, which will require mitigation measures to be taken if operation of the intake creates annoying noise levels off the pumping station site. Once this condition is complied with, operation and maintenance of the intake and its associated pumping

station will not cause impacts which render invalid the favorable cost-benefit analysis performed at the construction permit stage or require further mitigation measures for compliance with Section 102 of the National Environmental Policy Act of 1969, 42 U.S.C. § 4332 (1976).

IV. ORDER

WHEREFORE, in accordance with the Atomic Energy Act of 1954, as amended, and the Rules of Practice of the Commission, and based on the foregoing Findings of Fact and Conclusions of Law, IT IS ORDERED that:

1) Within one month after the proposed pumping station begins operation, the Applicant shall carry out the following noise measurements and calculations. Measurements shall be made between 12:00 a.m. and 4:00 a.m. at the site boundary at a point on the straight line between the transformers and Residence 4 (as shown in Policastro Testimony, ff. Tr. 1118, at Attachment 1) or at that point on the site boundary line where the maximum noise impact occurs (if that point is different). Measurements shall be obtained by reading the lowest level on the sound level meter (set on fast response) which is repeated several times (i.e., the mean minimum).

At the specified location the following measurements shall be made:

A. Measurement of the octave band sound pressure levels. From those measurements, the masking level shall be computed for the transformer fundamental frequencies at 120, 240, 360 and 480 Hz.

B. Measurements at the 1/3 octave bands for those four bands containing the fundamental frequencies.

The results of these measurements and computations shall be reported to the Staff.

The noise will be considered audible if the measured sound pressure level and the 1/3 octave band containing the fundamental frequency (from measurement B) is greater than the masking level computed (from measurement A) for that frequency. If any of the four transformer fundamentals is found to be audible, measures shall be taken promptly which render that fundamental (those fundamentals) inaudible.

If such measures are necessary or if any additional equipment which could affect the noise level is added, the measurements and computations described above shall be repeated and the results reported to the Staff.

2) In accordance with 10 C.F.R. §§ 2.760, 2.762, 2.764, 2.785, and 2.786, this Partial Initial Decision shall become effective and shall constitute, with respect to matters resolved herein, the final decision of the Commission thirty (30) days after issuance hereof, subject to any review pursuant to the above cited Rules of Practice. Applying the rationale of Boston Edison Co. (Pilgrim, Unit 2), ALAB-632, 13 NRC 91,

93 n. 2 (1981); Duke Power Co. (Perkins, Units 1, 2 and 3), ALAB-597, 11 NRC 870 (1980), and Houston Lighting and Power Co. (Allens Creek, Units 1 and 2), ALAB-301, 2 NRC 853 (1975), this partial initial decision is appealable at this time. Exceptions to this decision may be filed with the Atomic Safety and Licensing Appeal Board within ten (10) days after service of this Partial Initial Decision. A brief in support of such exceptions may be filed within thirty (30) days thereafter, forty (40) days in the case of the Staff. Within thirty (30) days after service of the brief of appellant, forty (40) days in the case of the Staff, any other party may file a brief in support of, or in opposition to such exceptions.

IT IS SO ORDERED.

FOR THE ATOMIC SAFETY
AND LICENSING BOARD

Lawrence Brenner, Chairman
ADMINISTRATIVE JUDGE

Dr. Richard F. Cole
ADMINISTRATIVE JUDGE

Dr. Peter A. Morris
ADMINISTRATIVE JUDGE

Bethesda, Maryland
March 8, 1983

An index of exhibits and witness qualifications
is attached as Appendix A [unpublished].

APPENDIX A

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

BEFORE ADMINISTRATIVE JUDGES:

Lawrence Brenner, Chairman
Dr. Richard F. Cole
Dr. Peter A. Morris

In the Matter of	ASLBP Docket No. 81-465-07 OL
PHILADELPHIA ELECTRIC COMPANY	(NRC Docket Nos. 50-352-OL 50-353-OL)
(Limerick Generating Station, Units 1 and 2)	March 8, 1983

PARTIAL INITIAL DECISION
(ON SUPPLEMENTARY COOLING WATER SYSTEM CONTENTIONS)

APPENDIX A

1. **Exhibits received into evidence:**

Staff Exhibits

No.		Received	Identified	Bound In
1	Drawing of American Shad, 21 mm. larva.		3223	3223
2	Exhibit 4 from Applicant Exhibit 2, Point Pleasant Pumping Station, Delaware River Channel Section at Water Intake.		3487	
3	Exhibit 5 from Applicant Exhibit 2, Point Pleasant Pumping Station Location and Layout Plan, General Profile, December 22, 1981, revised January 13, 1981.		3488	
4	Exhibit 10 from Applicant Exhibit 2, Point Pleasant Pumping Station Intake Screen Assembly and Piping Details, September 1, 1981, revised January 13, 1982.		3488	
5	Assessment of the impacts of the proposed Point Pleasant Pumping Station and intake structure on the shortnose sturgeon, by H. Brundage, 1982.		3501	

Del-Aware Exhibits

No.		Received	Identified	Bound In
1-A	Issue #1 Response on water quality data at Point Pleasant.	1313	1299	1315
1-B	Issue #2 Response on sea level elevation of Lumberville Dam.	1313	1300	1315
1-C	Issue #4 Response on further assessments of intake location after 1980 Environmental Assessment.	1313	1301	1315
1-D	Issue #6 Response on cross section data on Delaware River at Point Pleasant.	1313	1302	1315
1-E	Issue #7 Response on status of Point Pleasant withdrawal in Recommendation 13.	1316 (Rejected)	1302	1318
1-F	Issue #5 Response on current status of Merrill Creek project.	1317 (Rejected)	1302	1318
2	Tabulation of available data and Delaware River Flow Velocities at Intake Site (3).		1376	1376
3	Water Quality Analyses, Area-Specific Dilution Studies, Region III, January 1981.		1449	1478
4	Water Quality Analyses, Ten Area-Specific Dilution Studies.		1460	1478
5	Letter to Mr. Hansler from Mr. Torok dated March 12, 1980.		1465	1478
6	Letter to Col. Baldwin from Mr. Pence dated March 17, 1982.	1494	1471	1478
7	Development of Relationship Between Water Discharge and Water Surface Elevation, January 4, 1982.		1639	1727
8	Draft - Background Report Concerning the Interstate Water Management Recommendations of the Parties to the U.S. Supreme Court Decree of 1954 to the DRBC (Without Appendices).		1660	2509

No.		Received	Identified	Bound In
9	Letter to E.H. Bourquard from P.L. Harmon dated July 28, 1981 and three Tables on Velocity Measurements.	2225	2211	2225
10	The American Shad (Alosa sapidissima) in the Delaware River, by J.P. Miller, F.R. Griffiths and P.A. Thurston-Rogers.		2227	2229
11	Rating Curve - Point Pleasant Intake Site.		2275	2330
12	USGS Data Sheets for October 1980, May 1981 and July 1981.	2329	2320	2330
13	Point Pleasant Pumping Station Preliminary Design, Sheets 1, 2 and 3 of 4.		2321	2330
14	Letter to W.H. Dickinson from E.H. Bourquard dated August 10, 1982, including Tables.		2392	2392
15	Memorandum from W.H. Dickinson, "Mechanical Engineering Division," dated May 14, 1982.		2460	
16	Memorandum from D.L. Morad, "Making Water System Status Report," dated December 16, 1981.		2465	2509
17	Memorandum of meeting of January 5, 1982 (2 pages) including Figures and Excerpts of Hansen paper, by E.H. Bourquard.		2570	
18	Actual versus Measured Readings (Rangefinder) dated March 1981 (Tables) from handwritten note from Mr. Bourquard to Mr. Harmon dated March 10-11, 1981.		2758	2825
19	Delaware Intake Points Below, Read and Actual Distance from Split-Image Measuring Devices, E.H. Bourquard, dated March 10, 1981.		2768	2825
20	Letter from H.M. Brundage III to R.A. Flowers, dated July 27, 1982.		2966	2975

No.		Received	Identified	Bound In
21	Single page, marked "13," excerpted from "Assessment of the impacts of the proposed Point Pleasant Pumping Station and intake structure on the shortnose sturgeon."		2975	2975
22	Letter from H.M. Brundage III to E.H. Bourquard dated November 30, 1981.		3026	3027
23	Letter from C. Culp, U.S. Fish and Wildlife Service to R. Baldwin, dated September 14, 1982.		3342	
24	Photographs identified in McNutt testimony, including Cross-referenced Photo Numbers List.	3384	3384	
25	Policastro 1 with J.T. Phillippe's markings.		3748	3899
26	J.T. Phillippe's plotting of 17-18 points relating to Trenton.		3776	3899
27	Excerpts from Ecological Studies of the Nanticoke River and Nearby Area, Volume II, dated December 1980.		3953	

Applicant Exhibits

No.		Received	Identified	Bound In
1	Environmental Report Section (with index), including portions of Exhibits 1, 1A and 1B directly applicable to contentions.	949	937,974	950
1A	September 3, 1982 Responses to Requests for Additional Information.	949	938,974	
1B	September 17, 1982 Responses to Requests for Additional Information.	949	938,974	
2	January 22, 1982 letter from E.H. Bourquard to Corps of Engineers with Table 1.	1328	1324	1328
3	Applicant's list of Exhibits and other documents which the Licensing Board is requested to officially notice.		1334	1336
4	Map of Point Pleasant showing location of intake.	2154	2152	
5	Letter from P.L. Harmon to E.H. Bourquard (revision of Table 1 in November 1980 report), dated May 11, 1981.	2829	2829	2832
6	Letter from R.L. Baldwin, Corps of Engineers to H.N. Larsen, U.S. Fish and Wildlife Service, dated September 24, 1982, concerning Notice of Intent to Issue a Department of Army Permit to NWRA.		3179	3180

Board Exhibits

No.		Received	Identified	Bound In
1	Page 15 of "Biological Evaluation of the Proposed Water Intake in the Delaware River at Point Pleasant, Pennsylvania for NWRA" by P.L. Harmon, dated November 1980.		2637	
2	Cover letter from Mr. Richmond to Mr. Conner (index of contents); letter to Col. Baldwin from Pennsylvania Historic Museum Commission dated September 28, 1981; letter from Mr. Gordon of National Marine Fisheries Service to Mr. Sugarman dated September 30, 1982; letter from Mr. Hoffman of EPA to Mr. Cianfranni of Army Corps of Engineers dated August 5, 1982, signed by Col. Baldwin on October 14, 1982; Memorandum of Agreement between Corps of Engineers, the Advisory Council on Historic Preservation, and the State Historic Preservation Officer.		3955	

2. Professional Qualifications of Witnesses:

Professional Qualifications	Transcript Page
Vincent S. Boyer	933
W. Haines Dickinson, Jr.	933
E.H. Bourquard	933
Neil Moiseev	933
Anthony J. Policastro	1118
Brian J. Richter	1118
Paul L. Harmon	1321
John E. Edinger	1321
George D. Pence	1439
Charles E. Emery, III	1736
Michael Lee Kaufman	1736
Stanley Plevyak	1930
Harold M. Brundage, III	2965
Richard Hunt McNutt	3382
Rex G. Wescott	3490
Michael T. Masnik	3504
Jonathan T. Phillippe	3658
Pierce F. Lewis	4036

APPENDIX H

LIMERICK ACCIDENT SEQUENCES AND RELEASE CATEGORIES USED IN CONSEQUENCE ANALYSIS

APPENDIX H

LIMERICK ACCIDENT SEQUENCES AND RELEASE CATEGORIES USED IN CONSEQUENCE ANALYSIS

For the purpose of performing accident consequence analyses for the Limerick DES and FES, the staff requested Brookhaven National Laboratory (BNL) to help develop specifications of atmospheric release of radionuclides from severe accidents in the Limerick reactors based on the applicant's two probabilistic risk analyses (PRAs), Limerick Generating Station Probabilistic Risk Assessment (LGS-PRA)[1] and the Limerick Generating Station Severe Accident Risk Analysis (LGS-SARA).[2] The specifications included (1) identification of core-melt accident sequences leading to atmospheric release initiated by internal causes, fires, and earthquakes; (2) probabilities of the sequences; and (3) quantities and forms of radionuclides (source terms) and the other parameters necessary for appropriate characterization of atmospheric release from these sequences.

The ground rules recommended by the staff for the BNL analysis relate to the method of estimating source terms. There has been significant research activity in this area sponsored by both industry and the Commission since the publication of the Reactor Safety Study (RSS)[3] in 1975. Updated fission product source term assessment methods are currently being developed and are receiving extensive peer review. However, it is the judgment of the staff that the application of the evolving methodologies for assessment of source terms in licensing activities before they are thoroughly and carefully appraised would be premature. Therefore, the staff requested that BNL use the RSS prescriptions of fission product release from the damaged fuel, primary system holdup, credit for decontamination by suppression pool scrubbing, and fallout, plateout, and transport of radionuclides in the containment leading to atmospheric release. These RSS prescriptions are explained below.

In the RSS methodology, quantities of fission products released from the core material were based on four release components: gap, melt, oxidation, and vaporization. The gap release is modeled as a single event and is assumed to occur at accident initiation as the result of rupture of fuel cladding. It consists mostly of activity that would be released to void spaces within the fuel rods during normal reactor operation, and rapid depressurization of contained gases provides the driving force for escape. The melt release occurs from the fuel while it first heats to melting and becomes molten. High gasflows in the core during this period sweep the activity out of the core region. The melt release is divided into 10 equally sized releases evenly spaced between the time of core melt and the time of core slump. The oxidation release is modeled as a single release that occurs when the reactor pressure vessel (RPV) head fails and is the result of oxidation of that fraction of the core debris that is assumed to interact with water on the diaphragm floor or to fall into the suppression pool. Finely divided fuel material is scattered into an oxygen atmosphere and undergoes extensive oxidation, which liberates specific fission products. The vaporization release is assumed to start after vessel failure when core-concrete interactions begin. Turbulence caused by internal convection and melt sparging by gaseous decomposition products of concrete produce the driving forces for escape. The vaporization release is divided into 20 parts, 10 releases of exponentially decreasing magnitude in the first half hour followed by 10 more releases, also of exponentially decreasing magnitude, during the next 1½ hours.

Also in the RSS methodology, no specific credit for attenuation of fission products released from the RPV to containment building is allowed in the primary system. Thus, all the fission products released during the gap and melt release phases are assumed to enter the containment building.

For fission product attenuation as a result of scrubbing by water in the suppression pool, a decontamination factor (DF) of 100 is used for the subcooled pools and a DF of 1 is used for the saturated pools. (Noble gases and organic iodine are not subject to pool scrubbing.)

In the RSS methodology, the fission product transport within the containment building volumes is predicted using the CORRAL-II code. This code is used in conjunction with the fission product release model, pool scrubbing model, and the MARCH code.

As stated earlier, in the source term assessment made by BNL for use in the Limerick DES, only the RSS methodolgy was used. Use of the RSS methodology for Limerick may have resulted in over-estimates of source terms for some accident sequences and underestimates of source terms for others. However, because the evolving methodologies have not been fully appraised, the staff used its current practice of following the RSS source term assessment methodology in licensing evaluations. On balance, however, the staff has concluded that the risks estimated using the RSS source term methodology are reasonable, particularly when considered within the overall numerical uncertainties discussed in Section 5.9.4.5(7).

The staff worked with BNL during the analysis, and the final results have been reviewed by the staff and found adequate. Following the staff's guidelines, BNL developed 27 release categories for use in the Limerick DES. The same 27 release categories have also been used in the staff analysis in the FES. Characteristics of these release categories are shown in Table 5.11c and their likelihoods (point estimates of mean annual probabilities) in Table 5.11d. As noted in Section 5.9.4.5(2), source terms associated with four of the release categories in Table 5.11c, and probabilities of some of the release categories in Table 5.11d include revisions made after publication of the DES. For identification and quantification of these release categories, BNL considered (1) the sequence of events and conditions that could lead to core melt (accident damage states); (2) the containment building failure modes and radionuclide release paths; and (3) the actual characterization of radionuclide releases to the environment. Procedures used for identification of these release categories and their brief descriptions are summarized below.

Initially 67 plant damage states were identified for the Limerick reactors. Subsequently, however, 10 surrogate damage states were found to encompass these original 67 damage states. This was possible because many of the original damage states were found to be very similar in terms of the core-melt accident progression and containment failure characteristics. Table H.1 gives a brief description of each of the surrogate damage states and uses simple designators to identify the damage states for easy reference. The first six of the surrogate damage states given in Table H.1 include damage states discussed in LGS-PRA and NUREG/CR-3028,[4] but they also include the damage states initiated by fires and low to moderately severe earthquakes discussed in LGS-SARA. The last four of the surrogate damage states in Table H.1 include damage states discussed exclusively in LGS-SARA. Mean probabilities per reactor-year assigned to the 10 surrogate damage states are shown in Table H.2.

Using the 10 surrogate damage states, BNL performed analyses to determine the Limerick containment failure modes and radionuclide release characteristics using the MARCH/CORRAL computer code system*. Seven containment failure modes and release paths were identified (see Table H.3) and analyzed. They can be subdivided into leakage failures and structural failures. The leakage failures prevent the more catastrophic structural failure and, in some of the cases, make effective use of the standby gas treatment system (see Section 5.9.4.4(1)). The structural failures result in release pathways that either (1) bypass the suppression pool by failing the drywell or by causing the suppression pool to drain or (2) pass through the suppression pool. The mechanisms for developing these release pathways are overpressure from steam or noncondensibles, overpressure from hydrogen burns (for the containment deinerted cases), seismic (earthquake) failure of structures and systems, and steam explosion-induced failures. Analyses showed that there could be only 40 combinations of the 10 surrogate damage states and the 7 containment failure modes (and release paths) with non-zero probabilities (having any possibility of occurrence). The other 30 combinations were considered as essentially impossible.

The 40 combinations of surrogate damage states and containment failure modes (and leakage paths) were further reduced because the accident progressions resulting in radionuclude release to the atmosphere associated with a number of them are very similar. This resulted in 27 release categories for consequence analysis. These release categories are described in Table H.4. It should be noted that the labeling of each release category has been made both in terms of the surrogate damage state and the matching containment failure mode or leakage path.

As stated earlier, specifications (including the source terms) of each of the 27 release categories developed by BNL are shown in Table 5-11c. The timing of the radionuclide release, energy of release, duration of release, and warning time for evacuation shown in Table 5.11c were based on the MARCH analysis. The time of release is defined as the time of containment failure for those cases in which the meltdown would take place in an intact containment building. For those cases, when the containment building would fail prior to core damage, the time of release is defined as the start of core melting. The duration of release is defined as the time for the containment building to blowdown to

*The MARCH computer code used includes a new decay heat model based on the ANS-5.1-1979 standard. The 1979 standard produces an integrated decay heat over the first hour after the reactor shutdown about 20% greater than the 1971 standard used in the previous BNL review (NUREG/CR-3028)[4] of the LGS-PRA. The main effect of the new decay heat model has been the change in timing of major events during the progression of the accidents. The time to core meltdown, core slump, reactor pressure vessel failure, and containment failure predicted using the new decay heat model are significantly earlier than in NUREG/CR-3028.

atmospheric pressure. However, if the building fails first (meltdown into a failed containment building), the duration of release was defined to be from the start of core melting to the completion of vaporization release. The warning time is defined as the time period between the start of the core melt and the time of containment failure. If the containment building fails first, the warning time was defined as the time from the time of containment failure to the start of core melt. The energy of release is the energy release rate associated with the release at the time of containment failure. In those cases where the release could be spread out over many hours, the energy of release would be low. The height of release was chosen to be 25 m (82 ft) in all cases.

Following the guidelines provided by the staff, BNL subdivided the mean probability of each release category initiated by earthquakes into two parts. One part was associated with the release category that would be initiated by very severe earthquakes (effective peak ground acceleration equal to or in excess of 0.4g*), and the other part was associated with the same release category initiated by low to moderately severe earthquakes (effective peak ground acceleration less than 0.4g). The latter part was added to the mean probability of the same release category initiated by internal causes and fires. The rearranged mean probability for each release category is shown in Table 5.11d.

The purpose of such breakdown was to aid in making appropriate assumption regarding offsite emergency response in the consequence analysis. It was the judgment of the staff that earthquakes resulting in effective peak ground acceleration equal to or greater than about 0.4g would be of severity of Modified Mercalli (MM) intensity scale IX or worse.** Earthquakes of MM intensity scale IX or higher would be likely to seriously hamper the offsite emergency response efforts. (See Appendix I for description of offsite damages likely to be caused by earthquakes of various MM intensity scales.)

There are substantial uncertainties in the estimated mean probabilities shown in Table 5.11d. Further, the mean probability of a release category is not necessarily the representative of the full spectrum of values of its probability. Particularly for seismically induced release categories, values of probabilities span several orders of magnitudes between low and high estimates. However, it is the judgment of the staff that the use of the mean probabilities in consequence analysis, supplemented by discussion of uncertainties resulting from this use, provides a reasonable risk perspective. For discussion of uncertainties see Section 5.9.4.5(7).

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*g stands for acceleration due to gravity and is numerically about 32 feet per second per second.

**The lack of actual recording associated with this intensity and the controversy surrounding the definition of effective peak ground acceleration made the choice of 0.4g imprecise. A sensitivity analysis performed with a range of values of effective peak ground acceleration such as 0.35g to 0.5g would have been more appropriate. However, it was the staff's judgment that breakdown of probabilities of seismically induced release categories using several values from the range 0.35g to 0.5g of effective peak ground acceleration would not have resulted in probability sets very different from those obtained by using 0.4g.

REFERENCES

1. Letter, from PECo to NRC, submitting operating license application and a report, "Limerick Generating Station, Probabilistic Risk Assessment," March 17, 1981.

2. Letter, from E. J. Bradley, PECo, to A. Schwencer, NRC, submitting report "Limerick Generating Station, Severe Accident Risk Assessment," April 21, 1983.

3. U.S. Nuclear Regulatory Commission, NUREG-75/014, "Reactor Safety Study--An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants," October 1975 (formerly WASH-1400).

4. I. A. Papazoglou, et al., "Review of Limerick Generating Station Probabilistic Risk Assessment," U.S. Nuclear Regulatory Commission, NUREG/CR-3028, February 1983.

Table H.1 Description of surrogate damage states

Designator	Description
I-S	These are LOCA (loss-of-coolant accident)-initiated sequences (medium and small pipe breaks only) involving loss-of-coolant inventory makeup. They would result in a relatively fast core melt, with the containment intact at the time of core melt.
I-T	These are sequences initiated by transient events* involving loss-of-coolant inventory makeup. Core melt is expected to be relatively fast and the containment to be intact at the time of core melt.
II-T	These are transient- or LOCA-intiated sequences involving loss of containment heat removal or inadvertent steam relief valve opening accidents with inadequate heat removal capability. Core melt is expected to be relatively slow as a result of the lower decay power level, with the containment failing before core melt.
III-T	These sequences are transients involving loss of scram (fast shutdown of reactor) function and inability to provide coolant makeup, large LOCAs with insufficient coolant makeup, transients with loss of heat removal, and long-term loss-of-coolant inventory makeup. Core melt is expected to be relatively fast, and the containment intact at core melt.
IV-T	These sequences are transients that involve loss of scram function and a loss of containment heat removal or all reactivity control, but with coolant makeup capability. Core melt is expected to be relatively fast with the containment failing before core melt because of overpressure.
IV-A	As above but initiated by large LOCAs.
IS-$\bar{C}$	These sequences are seismically (earthquake) induced sequences that lead to failure of the coolant inventory/makeup systems and a breach of wetwell integrity with the reactor scrammed. Core melt is expected to be fast, with the containment failing before core melt because the residual heat removal (RHR) system suction lines are severed.
IS-C	As above, but coupled with a loss of the scram function.
S-H2O	These sequences are seismically induced reactor vessel failures (plus random reactor-vessel failure), coupled with immediate containment failure. Core melt is fast, with the vessel and containment both failed at the time of core melt. This sequence assumes the vessel break is high, which would allow water to be retained in the bottom of the vessel before core slump.

*See next page for footnote.

Table H.1 (Continued)

Designator	Description
S-$\overline{H20}$	As above, but with a vessel failure location that results in complete draining of the water from the vessel.

*In general, the term reactor transient applies to any significant deviation from the normal operating values of any of the key reactor operating parameters. More specifically, transient events can be assumed to include all those situations (except for the LOCA, which is treated separately) that could lead to fuel heat imbalances. When viewed in this way, transients cover the reactor in its shutdown condition as well as in its various operating conditions. The shutdown condition is important in the consideration of transients because many transient conditions result in shutdown of the reactor, and decay heat removal systems are needed to prevent fuel heat imbalances as a result of core decay heat.

Transients may occur as a consequence of an operator error or the malfunction or failure of equipment. Many transients are handled by the reactor control system, which would return the reactor to its normal operating condition. Others would be beyond the capability of the reactor control system and would require reactor shutdown by the reactor protection system to avoid damage to the reactor fuel.

In safety analyses, the principal areas of interest are increases in reactor core power (heat generation), decreases in coolant flow (heat removal), and increases in reactor coolant system (RCS) pressure. Any of these could potentially result from a malfunction or failure, and they represent a potential for damage to the reactor core and/or the pressure boundary of the RCS. The analysis of reactor transients has been directed at identifying those malfunctions or failures that can cause core melting or rupture of the RCS pressure boundary. Regardless of the way in which transients might cause core melting, the consequences are essentially the same; that is, the molten core would be inside the containment and would follow the same course of events as a molten core that might result from a LOCA.

Each potential transient is assessed to fall into either one of two general categories, the anticipated (likely) transients and the unanticipated (unlikely) transients. The large majority of potential transients are those that have become commonly known as anticipated transients. All other transients are considered to fall into the unanticipated transients category. The relatively low probability (unanticipated) transients can be eliminated from the risk determination because their potential contribution to risk is small compared to that of the more likely (anticipated) transients that would produce the same consequences.

The anticipated transient initiators for which successful reactor scram could be accomplished have been divided into five groups for analysis of the Limerick reactors. These groups are

Table H.1 (Continued)

(1) transients resulting in turbine trip
(2) transients leading to isolation of the reactor vessel from the main condenser, a main steamline isolation valve (MSIV) closure, and loss of feedwater
(3) transients resulting from loss of offsite power
(4) transients resulting from inadvertent open relief valve (IORV)
(5) orderly and controlled manual shutdown

Thirty-seven BWR transients identified from operating experience data are listed in Table 2.9 of NUREG/CR-3028[4] and are included in the first four of the above groups. If the reactor protection system fails to scram the reactor after an initiating event in any of the first four transient groups, then an anticipated transient without scram (ATWS) condition results. The following four groups of ATWS initiators were, therefore, considered:

(1) turbine trip ATWS
(2) MSIV closure ATWS
(3) loss of offsite power ATWS
(4) IORV ATWS

Table H.2 Mean (point estimate) probabilities of surrogate damage states by initiating events

Surrogate damage state	Probability per reactor-year			
	Internal causes	Fires	Low to moderately severe earthquakes (EPA* < 0.4g)**	Severe earthquakes (EPA* ≥ 0.4g)**
I-S	8(-8)***			
I-T	8(-5)	3(-6)	9(-7)	2(-6)
II-T	4(-6)		1(-8)	4(-8)
III-T	3(-6)		8(-8)	7(-7)
IV-T	3(-7)		2(-8)	1(-7)
IV-A	5(-9)			
IS-$\overline{C}$			1(-7)	9(-7)
IS-C			1(-8)	1(-7)
S-H2O	1(-8)			4(-8)
S-$\overline{H2O}$	1(-8)			4(-7)
TOTAL	9(-5)	3(-6)	1(-6)	4(-6)

*EPA stands for effective peak ground acceleration.

**g stands for an acceleration equal that due to gravity and is numerically equal to 32 feet per second per second

***8(-8) = 8 x 10^{-8}

NOTE: Please see Section 5.9.4.5(7) for discussion of uncertainties. Estimated numbers were rounded to one significant digit only for the purpose of this table.

Table H.3 Containment failure mode and release path notation

Designator	Description
DW	Containment failure via overpressurization. Failure location in the drywell.
WW	Containment failure via overpressurization. Failure location in the wetwell above the suppression pool.
$\overline{\mathrm{WW}}$	Containment failure via overpressurization. Failure location in the wetwell below the suppression pool resulting in loss of suppression pool water.
SE	Failure via in-vessel steam explosion-generated missiles.
HB	Failure via hydrogen burning during the periods when the containment atmosphere is de-inerted. This failure mode also includes hydrogen detonation and ex-vessel steam explosion failure modes, which are of very low frequency.
LGT	Containment leakage rates sufficiently low to allow the standby gas treatment system (SGTS) to operate effectively.
$\overline{\mathrm{LGT}}$	Containment leakage rates so high that the SGTS is ineffective.

Table H.4 Description of the release categories

Category	Description
1. RELEASE CATEGORIES ASSOCIATED WITH SURROGATE DAMAGE STATE I-T	The damage state I-T is defined in Table H.1 and basically consists of transients with loss-of-coolant inventory makeup. Core melt in such situations is expected to be relatively fast and occurs within an intact containment. After vessel failure, the majority of the core materials are retained on the diaphragm floor below the reactor vessel. Containment failure occurs via gradual overpressurization (except for SE, HB, LGT and LGT release -- see Table H.3) several hours after vessel failure as a result of core/concrete interactions.
I-T/DW	This release category assumes an overpressure failure in the drywell wall. The gap and melt releases would be directed to the suppression pool and subjected to a DF of 100 (water is subcooled) before they reach the wetwell airspace. The vaporization release would be directed to the drywell without any pool scrubbing. All fission products in the drywell and wetwell would be subjected to agglomeration and settling as predicted by the CORRAL code before vessel failure, several hours after the pressure vessel failure.
I-T/WW	This release category assumes a failure in the wetwell above the suppression pool. The gap, melt, and vaporization releases would be released to the drywell and wetwell as described above. The only difference is that when the containment fails, fission products in the drywell must pass through the downcomers and suppression pool before they are released to the atmosphere.

Table H.4 (Continued)

Category	Description
I-T/$\overline{WW}$	This release category assumes a failure in the wetwell below the suppression pool, which drains the water. The gap, melt, and vaporization releases would be released to the containment as described above. The only difference is that at containment failure the suppression pool would be drained so that fission products in the drywell no longer have to pass through the suppression pool (as in the I-T/WW release path) before they are released to atmosphere.
I-T/SE	This release category results from an in-vessel steam explosion-generated missile. BNL assumed this occurs at core slump and opens a direct path from the primary system to atmosphere. In the LGS-PRA, this failure mode was similar to RSS release category BWR-1. The release corresponds to an anticipated transient without scram sequence analyzed in Appendix V of the RSS, in which the steam explosion was assumed to occur after only 13% of the core had melted. Consequently, most of the melt release would be released to containment without pool scrubbing. However, BNL used a steam explosion release that more appropriately reflects BNL's analysis of the sequence.
I-T/HB	This release category could result from hydrogen burn failures during the time when the containment atmosphere is de-inerted. BNL used the same release category as in the LGS-PRA, but reduced the core fraction associated with the oxidation releases in a manner consistent with WASH-1400. (Note in the LGS-PRA, this release category was representative of ex-vessel steam explosions.)

Table H.4 Description of the release categories

Category	Description
I-T/LGT and I-T/$\overline{LGT}$	These release categories result from containment leakage and assume that the SGTS operates (LGT), or that it does not operate ($\overline{LGT}$). BNL used the LGS-PRA releases, but changed the timing to correspond to the BNL MARCH analysis.
2. RELEASE CATEGORIES ASSOCIATED WITH SURROGATE DAMAGE STATE II-T	The damage state II-T is defined in Table H.1 and basically assumes loss of containment heat removal. Eventually, the containment would fail and cause the loss of inventory makeup. As the containment would fail prior to core melt and the suppression pool is saturated (DF of 1), the location of containment failure (DW, WW or $\overline{WW}$ -- see Table H.3) is of rather less importance than it is for the I-T damage states.
II-T/WW	This release category assumes a failure in the wetwell above the suppression pool. The melt release would be directed to the suppression pool, but would not be subjected to pool decontamination because the water would be saturated. The vaporization release would be directed to the drywell, then through the downcomers to the wetwell air space, and finally to the atmosphere. This one failure location was also used to represent failures in the drywell (DW) and wetwell below the suppression pool ($\overline{WW}$). This assumption is reasonable because, as the pool is saturated, the different flow paths would not result in significant differences in calculated release fractions (see IV-T below).
II-T/SE	This release category results from an in-vessel steam explosion generated missile. The release path used in the LGS-PRA, which was taken from Appendix V of the RSS, was considered appropriate and was used. Differences relate only to the timing, which now corresponds to the present analysis of a II-T damage state.

Table H.4 Description of the release categories

Category	Description
3. RELEASE CATEGORIES ASSOCIATED WITH SURROGATE DAMAGE STATE III-T	The damage state III-T corresponds to a transient event coupled with loss of scram function (see Table H.1). Core melt would be rapid and into an intact containment. Containment failure is predicted to occur after vessel failure as a result of overpressurization. However, the suppression pool would be saturated so that the gap, melt, and vaporization releases would not be subjected to decontamination by the pool. Consequently, again (as for the II-T damage state) one failure location was used to represent the three potential locations.
III-T/WW	This release category is similar to the I-T/WW sequence; however, because the pool is saturated, the melt release would not be subjected to pool scrubbing.
III-T/SE	The steam explosion release category used in the LGS-PRA was considered appropriate and was used. Differences in conditions postulated were related only to timing, which was made consistent with a MARCH thermal-hydraulics analysis.
III-T/HB, III-T/LGT and III-T/$\overline{\text{LGT}}$	These release categories are also considdered as possible and would be similar to I-T/HB, I-T/LGT and I-T/$\overline{\text{LGT}}$, respectively.
4. RELEASE CATEGORIES ASSOCIATED WITH SURROGATE DAMAGE STATE IV-T	The damage state IV-T is defined in Table H.1 and essentially consists of ATWS sequences in which continued coolant makeup was postulated to result in overpressurization failure of the containment before core melt. The suppression pool would be saturated for these sequences and hence the DF would be unity.
IV-T/DW, IV-T/WW and IV-T/$\overline{\text{WW}}$	For these release categories, the impacts of the three potential failure locations (DW, WW, and $\overline{\text{WW}}$) were analyzed. Because of the saturated pool, similar release fractions were estimated. These calculations support the use of only one failure location for the II-T and III-T damage states. The release paths (DW, WW, and $\overline{\text{WW}}$) for the three locations are discussed in detail above.

Table H.4 Description of the release categories

Category	Description
IV-T/SE	The steam explosion release category used in the LGS-PRA for Class III (damage state III-T) was considered appropriate to this damage state. Consequently, this release category is used, with the timing changed to be consistent with the BNL MARCH analysis.
5. RELEASE CATEGORIES ASSOCIATED WITH SURROGATE DAMAGE STATES I-S AND IV-A	The damage states I-S and IV-A are defined in Table H.1 and correspond to LOCA-initiated sequences. They were calculated to have a low frequency but, because of differences in flow paths relative to transients, were analyzed separately.
I-S/DW	This release category would result in the release of the melt and vaporization releases to the drywell, thus bypassing pool scrubbing. However, because the containment would fail several hours after vessel failure, the release fractions are not significantly different from the I-T/DW flow path (in which the gap and melt releases were subjected to suppression pool scrubbing.)
IV-A/DW	This release category is similar to IV-T/DW except that the initiating event is a large LOCA.
6. RELEASE CATEGORIES ASSOCIATED WITH SURROGATE DAMAGE STATES IS-C AND IS-$\bar{C}$	The damage states IS-C and IS-$\bar{C}$ are defined in Table H.1 and could be induced by earthquakes. The RHR suction lines could be severed, resulting in partial loss of the suppression pool. The gap and melt releases would be directed to the suppression pool and subjected to decontamination (the water would be subcooled and the DF = 100) before release via the severed RHR suction lines. The vaporization release would be directed to the drywell and then flow through the downcomers into the wetwell. However, as the suppression pool would be drained below the downcomer outlet, the vaporization release would not be subject to pool scrubbing. The difference between IS-C and IS-$\bar{C}$ relates to the scram function and does not influence the flow paths; only the timing of the sequence is affected.

Table H.4 Description of the release categories

Category	Description
IS-C/DW and IS-$\overline{\text{C}}$/DW	The failure mode for these release categories was considered to be similar to a DW mode in LPG-SARA. However, this should not be interpreted as a failure location in the drywell. Rather, for release analysis purposes, a containment failure of the type DW is postulated.
IS-C/SE and IS-$\overline{\text{C}}$/SE	For these release categories, the in-vessel steam explosion failures were assumed to be similar to the I-T/SE release. Only the timing was altered to reflect the MARCH analysis.
7. RELEASE CATEGORIES ASSOCIATED WITH SURROGATE DAMAGE STATES S-H20 AND S-$\overline{\text{H20}}$	The damage states S-H20 and S-$\overline{\text{H20}}$ are defined in Table H.1; they also would be earthquake induced. The RHR suction lines would be severed, but the vessel also could fail at the start of the accident. Thus, the core would melt into a failed containment and none of the releases would be subjected to pool scrubbing. The only differences between the S-H20 and S-$\overline{\text{H20}}$ sequences relate to the location of possible failure in the vessel. For the S-H20 sequence, water would remain in the vessel and be available for interacting with core debris as slumping occurs. This would affect movement of the fission products and allow the potential for an in-vessel steam explosion. The S-$\overline{\text{H20}}$ damage state involves a failure of the vessel so that the water would be completely drained at the start of the accident. Thus, there would be no in-vessel debris/water interaction and no potential for an in-vessel steam explosion.
S-H20/$\overline{\text{WW}}$, S-$\overline{\text{H20}}$/SE and S-$\overline{\text{H20}}$/$\overline{\text{WW}}$	These release categories are considered possible. Assignment of $\overline{\text{WW}}$ failure mode to damage states S-H20 and S-$\overline{\text{H20}}$ relates only to similarity of fission product release path and lack of suppression pool scrubbing, rather than the actual failure location.

APPENDIX I

DESCRIPTION OF POTENTIAL OFFSITE DAMAGES FROM EARTHQUAKES OF VARIOUS INTENSITIES, ACCORDING TO THE MODIFIED MERCALLI INTENSITY SCALE OF 1931

APPENDIX I

DESCRIPTION OF POTENTIAL OFFSITE DAMAGES FROM EARTHQUAKES OF VARIOUS INTENSITIES, ACCORDING TO THE MODIFIED MERCALLI INTENSITY SCALE OF 1931

[Adapted from Seiberg's Mercalli-Cancani scale, modified and condensed.]

I.
- a. Not felt, except rarely under especially favorable circumstances. Under certain conditions, at and outside the boundary of the area in which a great shock is felt.
- b. Sometimes birds or animals reported uneasy or disturbed.
- c. Sometimes dizziness or nausea experienced.
- d. Sometimes trees, structures, liquids, bodies of water may sway, doors swing very slowly.

II.
- a. Felt indoors by few, especially on upper floors, or by sensitive, or nervous persons.
- b. Sometimes hanging objects may swing, especially when delicately suspended.
- c. Sometimes trees, structures, liquids, bodies of water may sway, doors swing very slowly.
- d. Sometimes birds or animals reported uneasy or disturbed.
- e. Sometimes dizziness or nausea experienced.

III.
- a. Felt indoors by several persons.
- b. Motion, usually rapid vibration.
- c. Sometimes not recognized to be an earthquake at first.
- d. Duration estimated in some cases.
- e. Vibration like that due to passing of light or lightly loaded trucks or heavy trucks some distance away.
- f. Hanging objects may swing slightly.
- g. Movements may be appreciable on upper level of tall structures.
- h. Standing motorcars rocked slightly.

IV.
- a. Felt indoors by many, outdoors by few.
- b. Awakened few, especially light sleepers.
- c. Frightened no one, unless apprehensive from previous experience.
- d. Vibration like that due to passing of heavy or heavily loaded trucks.
- e. Sensation like heavy body striking building, or falling of heavy objects inside.
- f. Rattling of dishes, windows, doors; glassware and crockery clink and clash.
- g. Creaking of walls, frame, especially in the upper range of this grade.

h. Hanging objects swing in numerous instances.
i. Liquids in open vessels slightly disturbed.
j. Standing motorcars rocked noticeably.

V.
a. Felt indoors by practically all; outdoors by many or most.
b. Outdoors direction estimated.
c. Awakened many or most.
d. Frightened few, slight excitment, a few ran outdoors.
e. Buildings trembled throughout.
f. Dishes, glassware broken to some extent.
g. Windows cracked in some cases, but not generally.
h. Vases, small or unstable objects overturned, in many instances, with occasional falls.
i. Hanging objects, doors, swing generally or considerably.
j. Pictures knocked against walls or swung out of place.
k. Doors, shutters opened or closed abruptly.
l. Pendulum clocks stopped, started, or ran fast, or slow.
m. Small objects, furnishings moved, the latter to a slight extent.
n. Liquids spilled in small amounts from well-filled open containers.
o. Trees, bushes shaken slightly.

VI.
a. Felt by all, indoors and outdoors.
b. Frightened many; excitement general; some alarm; many ran outdoors.
c. Awakened all.
d. Persons made to move unsteadily.
e. Trees, bushes shaken slightly to moderately.
f. Liquid set in strong motion.
g. Small bells rang--church, chapel, school, etc.
h. Damage slight in poorly built buildings.
i. Fall of plaster in small amount.
j. Plaster cracked somewhat, especially fine cracks (in) chimneys in some instances.
k. Dishes, glassware broken in considerable quantity, also some windows.
l. Knickknacks, books, pictures fall.
m. Furniture overturned in many instances.
n. Moderately heavy furnishings moved.

VII.
a. Frightened all; general alarm, all ran outdoors.
b. Some, or many, found it difficult to stand.
c. Noticed by persons driving motorcars.
d. Trees and bushes shaken moderately to strongly.
e. Waves on ponds, lakes, and running water.
f. Water turbid from stirred-up mud.
g. Incaving to some extent of sand or gravel stream banks.
h. Large church bells, etc. rang.
i. Suspended objects quiver.
j. Damage negligible in buildings of good design and construction.

k. Damage slight to moderate in well-built ordinary buildings; considerable in poorly built or badly designed buildings, adobe houses, old walls (especially without mortar), spires, etc.
l. Chimneys cracked to considerable extent, walls to some extent.
m. Fall of plaster in considerable to large amounts; also some stucco falls.
n. Numerous windows broken; furniture to some extent.
o. Loosened brickwork and tiles shaken down.
p. Weak chimneys broken at the roofline (sometimes damaging roofs).
q. Cornices fall from towers and high buildings.
r. Bricks and stones dislodged.
s. Heavy furniture overturned, with damage from breaking.
t. Considerable damage to concrete irrigation ditches.

VIII. a. Fright general; alarm approaches panic.
b. Persons driving motorcars disturbed.
c. Trees shaken strongly; branches, trunks broken off, especially palm trees.
d. Sand and mud ejected in small amounts.
e. Temporary and permanent changes in flow of springs and wells; dry wells renewed flow, temperature changes in spring and well waters.
f. Damage slight in structures (brick) built especially to withstand earthquakes.
g. Damage considerable in ordinary substantial buildings: partial collapse, racked; tumbled down wooden houses in some cases; threw out panel walls in frame structures; decayed piling broken off.
h. Walls fall.
i. Cracked, broke solid stone walls seriously; wet ground to some extent, also ground on steep slopes.
j. Chimneys, columns, monuments, factory stacks, towers twist, fall.
k. Very heavy furniture moved conspicuously, overturned.

IX*. a. Panic general
b. Ground cracked conspicuously.
c. Damage considerable in (masonry) structures built especially to withstand earthquakes.
d. Some wood frame houses built especially to withstand earthquakes, thrown out of plumb.
e. Damage great in substantial (masonry) buildings, some collapse in large part; wholly shifted frame buildings off foundations, racked frames.
f. Damage serious to reservoirs.
g. Underground pipes sometimes broken.

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*It is the staff's judgment that MM Intensity Scale of IX and higher would be associated with effective peak ground acceleration of about or greater than 0.4g.

X. a. Ground cracked, especially when loose and wet, up to widths of several inches; fissures up to a yard in width parallel to canal and stream banks.
b. Landslides considerable from river banks and steep coasts.
c. Sand and mud shifted horizontally on beaches and flat land.
d. Level of water in wells changed.
e. Water thrown on banks of canals, lakes, rivers, etc.
f. Damage serious to dams, dikes, embankments.
g. Damage severe to well-built wooden structures and bridges, some destroyed.
h. Dangerous cracks developed in excellent brick walls.
i. Most masonry and frame structures destroyed, also their foundations.
j. Railroad rails bent slightly.
k. Pipelines buried in earth torn apart or crushed endwise.
l. Open cracks and broad wavy folds in cement pavements and asphalt road surfaces.

XI. a. Many and widespread disturbances in ground, varying with ground material.
b. Broad fissures, earth slumps, and land slips in soft, wet ground.
c. Water ejected in large amounts charged with sand and mud.
d. Sea-waves (tidal waves) of significant magnitude.
e. Damage severe to wood frame structures, especially near shock centers.
f. Damage great to dams, dikes, embankments, often for long distances.
g. Few, if any, masonry structures remained standing.
h. Large, well-built bridges destroyed by the wrecking of supporting piers, or pillars.
i. Yielding wooden bridges affected less.
j. Railroad rails bent greatly and thrust endwise.
k. Pipelines buried in earth put completely out of service.

XII. a. Damage total--practically all works of construction damaged greatly or destroyed.
b. Disturbances in ground great and varied, numerous shearing cracks.
c. Landslides, falls of rock of significant character, slumping of river banks, etc., numerous and extensive.
d. Large rock masses wrenched loose, torn off.
e. Fault slips in firm rock, with notable horizontal and vertical offset displacements.
f. Water channels, surface and underground, disturbed and modified greately.
g. Lakes dammed, waterfalls produced, rivers deflected, etc.
h. Waves seen on ground surfaces (actually seen, probably, in some cases).
i. Lines of sight and level distorted.
j. Objects thrown upward into the air.

APPENDIX J

CONSEQUENCE MODELING CONSIDERATIONS

APPENDIX J

CONSEQUENCE MODELING CONSIDERATIONS

J.1 Evacuation Model

"Evacuation," used in the context of offsite emergency response in the event of substantial amount of radioactivity release to the atmosphere in a reactor accident, denotes an early and expeditious movement of people to avoid exposure to the passing radioactive cloud and/or to acute ground contamination in the wake of the cloud passage. It should be distinguished from "relocation" which denotes a post-accident response to reduce exposure from long-term ground contamination. The Reactor Safety Study (RSS) (WASH-1400, NUREG-75/014) consequence model contains provision for incorporating radiological consequence reduction benefits of public evacuation. The benefits of a properly planned and expeditiously carried out public evacuation would be manifested in a reduction of early health effects associated with early exposure; namely, in the number of cases of early fatality (see Section J-2) and acute radiation sickness that would require hospitalization. The evacuation model originally used in the RSS consequence model is described in WASH-1400 as well as in NUREG-0340. However, the evacuation model that has been used herein is a modified version (SAND 78-0092) of the RSS model and is, to a certain extent, oriented toward site emergency planning by inclusion of site-specific delay time before evacuation and effective evacuation speed as model parameters. The modified version is incorporated into the current version of the CRAC code (and the CRAC2 code which is a modified version of CRAC) and is briefly outlined below.

The model assumes that people living within portions of a circular area with a specified radius (such as the 10-mile (16-km) plume exposure pathway Emergency Planning Zone (EPZ)), with the reactor at the center, would evacuate if an accident should occur involving imminent or actual release or significant quantities of radioactivity to the atmosphere.

Significant atmospheric releases of radioactivity would in general be preceded by one or more hours of warning time (postulated as the time interval between the awareness of impending core melt and the beginning of the release of radioactivity from the containment building)--although for some specific release categories the warning time could be less than an hour. For the purpose of calculation of radiological exposure, the model assumes that those people who would potentially be under the radioactive cloud that would develop following the release would leave their residences after a specific amount of delay time* and then evacuate. The delay time is reckoned from the beginning of the warning time and is recognized as the sum of the time required by the reactor operators to notify the responsible authorities; the time required by the authorities to interpret the data, decide to evacuate, and direct the people to evacuate; and the time required for the people to mobilize and get underway.

*Assumed to be of constant value which would be the same for all evacuees.

The model assumes that while leaving the area each evacuee would move radially out and in the downwind direction* with an average effective speed** (obtained by dividing the zone radius by the average time taken to clear the zone after the delay time) over a fixed distance** from the evacuee's starting point. The fixed distance used in the analysis discussed in Section 5.9.4.5(2) was selected to be 15 miles (24 km) (which is 5 miles (8 km) more than the 10-mile (16-km) plume exposure pathway EPZ radius). After reaching the end of the travel distance, the evacuee is assumed to receive no further radiation exposure. In a real evacuation, paths of evacuees would be dictated by the site road net-work. However, each segment of actual trajectory of an evacuee would project a component in the downwind direction which, in the consequence model, is assumed to be radial. Therefore, each evacuee's actual motion would have a component of motion along the radial downwind direction. The evacuation model assumption that evacuees originating from areas that would come under the radioactive cloud would move radially out over a certain distance amounts to only an artifice for dose calculation: as if the evacuee's radiological exposure is due to their component motion along the radial downwind direction (over a component path length which is assumed to be 15 miles).

The model incorporates a finite length of the radioactive cloud in the downwind direction; this would be determined by the product of the duration over which the atmospheric release would take place and the average windspeed during the release. It is assumed that the front and the back of the cloud formed would move with an equal speed, which would be the same as the prevailing windspeed; therefore, its length would remain constant. At any time after the release, the concentration of radioactivity is assumed to be uniform over the length of the cloud. If the delay time would be less than the warning time, then all evacuees would have a head start, i.e., the cloud would be trailing behind the evacuees initially. On the other hand, if the delay time would be more than the warning time, then, depending on initial locations of the evacuees there are possibilities that (1) an evacuee would still have a head start, (2) the cloud would already be overhead when an evacuee starts out to leave, or (3) an evacuee would be initially trailing behind the cloud. However, this initial picture of cloud-people disposition would change as the evacuees travel, depending on the relative speeds and positions between the cloud and people. It is possible that the cloud and an evacuee would overtake one another one or more times before the evaucee would reach his or her destination. In the model, the radial position of an evacuating person, while stationary or in transit, is compared to the front and the back of the cloud as a function of time to determine a period of exposure to airborne radionuclides. The model calculates the time periods during which people are exposed to radionuclides on the ground while they are stationary and while they are evacuating. Because radionuclides would be deposited continually from the cloud as it passed a given location, a person while under the cloud would be exposed to ground contamination less concentrated than if the cloud had completely passed. To account for this reasonably, the revised model assumes that persons are exposed to the total ground contamination when completely passed by the cloud; to one half the calculated concentration when they are anywhere under the cloud; and to no concentration when they are in front of the cloud.

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*In the RSS consequence model and the CRAC and CRAC2 codes, the radioactive cloud is assumed to travel radially outward only.

**Assumed to be a constant value for all evacuees.

The model provides for use of different values of the shielding protection factors for exposure from airborne radioactivity and contaminated ground for stationary and moving evacuees during delay and transit periods.

The model has the same provision for calculation of the economic cost associated with implementation of evacuation as in the original RSS model. For this purpose, the model assumes that for atmospheric releases of durations 3 hours or less, all people living within a circular area of 5-mile (8-km) radius centered at the reactor, plus all people within a 90° angular sector within the plume exposure pathway EPZ and centered on the the downwind direction, will evacuate and temporarily relocate. However, if the duration of release exceeds 3 hours, the cost of evacuation is based on the assumption that all people within the entire plume exposure pathway EPZ would evacuate and temporarily relocate. For either of these situations, the cost of evacuation and relocation is assumed to be $225 (1980 dollar) per person, which includes cost of food and temporary sheltering for a period of 1 week.

J.2 Early Health Effects Model

The medical advisors to the RSS (WASH-1400, Appendix IV, Section 9.2.2, and Appendix F) proposed three alternative dose-mortality relationships that can be used to estimate the number of early fatalities that might result in an exposed population. These alternatives characterize different degrees of postexposure medical treatment from "minimal," to "supportive," to "heroic"; they are more fully described in NUREG-0340. There is uncertainty associated with both the mortality relationships (NUREG/CR-3185), and the availability and efficacy of different classes of medical treatment (Elliot, 1982). Estimates of the early fatility risks using the dose-mortality relationship that is based upon the supportive treatment alternative are presented in the texts of Section 5.9.4.5. This implies the availability of medical care facilities and services for those exposed in excess of 175 rems, the approximate level that the medical advisors to the RSS indicated would be indicative of the potential need for more than minimum services to reduce early fatality risks. At the extreme low probability end of the spectrum (i.e., at the 1 chance in 100 million per reactor-year level), the number of persons involved might exceed the capacity of facilities for such services, in which case the number of early fatalities might have been underestimated. To gain perspective on this element of uncertainty, the staff has also performed calculations using the most pessimistic dose-mortality relationship based upon WASH-1400 medical experts' estimated dose-mortality relationship for minimal medical treatment and using identical assumptions regarding offsite emergency response as made in Section 5.9.4.5. These results are also presented in Section 5.9.4.5. The staff has also considered the uncertainties associated with the WASH-1400 dose-mortality relationship for minimal medical treatment and has concluded that early fatality risk estimates as bounded by the uncertainties discussed in Section 5.9.4.5(7) are reasonable. This is because it is inconceivable that a major reactor accident at Limerick would not be followed by a mobilization of medical services, services which can be expected to reduce mortality risks to less than those indicated by the WASH-1400 description of minimal medical treatment.

J.3 References

Elliot, D.A., Task 5 letter report from Dr. D. A. Elliot of Andrulis Research Corp. to Ms. A. Chu, NRC Project Officer, on Technical Assistance Contract No. NRC-03-82-128, December 13, 1982.

Sandia Laboratories, "A Model of Public Evacuation for Atmospheric Radiological Releases," SAND-78-0092, June 1978.

U.S. Nuclear Regulatory Commission, NUREG-75/014, "Reactor Safety Study--An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants," formerly WASH-1400, October 1975.

---, NUREG-0340, "Overview of the Reactor Safety Study Consequences Model," October 1977.

---, NUREG/CR-3185, "Critical Review of the Reactor Safety Study Radiological Health Effects Model," Sandia Laboratories (also SAND-82-7081) March 1983.

APPENDIX K

CONDITIONAL MEAN VALUES OF ACCIDENT CONSEQUENCES

APPENDIX K

CONDITIONAL MEAN VALUES OF ACCIDENT CONSEQUENCES

The conditional mean values of potential societal consequences of several kinds from each release category in Table 5.11c are shown in Table K.1. These means were calculated by the CRAC code and represent averages of each kind of consequence for each release category over the spectrum of the Limerick site meterological conditions. "Conditional" mean values are so called because these mean values are conditional upon the occurrence of the accidents represented by the release categories. Probabilities of release categories have not been factored into these mean value estimates. The conditional mean values are provided for a perspective only; they are devoid of much importance without simultaneous association of probabilities of the release categories to which the mean values are due. They are useful, however, in judging the relative importance of different sequences.

Table K.1 is useful for risk calculations. It can be used to calculate the risk of any particular kind of consequence (shown in the table) from any of the listed release categories by simply multiplying the conditional mean value of the given consequence by the probability per reactor-year (Table 5.11d) of the release category to which the mean value is due. It can also be used to calculate the risk of any particular kind of consequence from a group of release categories by calculating the sum of the products of the conditional mean values of the consequence and the probabilities of the respective release categories in the group; the group may include some or all of the release categories.

Table K.1 Conditional mean values of societal consequences from individual release categories for three alternative offsite emergency response modes

Consequence Category	Offsite Emergency Response Mode	Release Categories									
		I-T/DW	I-T/WW	I-T/$\overline{WW}$	I-T/SE*	I-T/HB	I-T/$\overline{LGT}$	II-T/WW	III-T/WW	III-T/HB	III-T/LGT
1. Early fatalities with supportive medical treatment (persons)	Evac-Reloc	0	0	0	2(2)**	1(1)	5(-1)	0	0	1(1)	0
	Early Reloc	1(0)	0	0	7(1)	1(1)	1(0)	2(2)	3(1)	1(1)	0
	Late Reloc	3(1)	5(-1)	5(-1)	---	1(2)	5(1)	2(3)	4(2)	2(2)	2(-2)
2. Population receiving in excess of 200 Rems total marrow dose from early exposure (persons)	Evac-Reloc	0	0	0	2(3)	4(2)	4(1)	5(2)	2(3)	4(2)	3(0)
	Early Reloc	1(1)	0	0	1(3)	3(2)	2(1)	2(3)	2(3)	3(2)	0
	Late Reloc	1(2)	3(0)	1(0)	--	1(3)	9(2)	5(3)	7(3)	1(3)	5(0)
3. Early injuries (persons)	Evac-Reloc	4(1)	0	0	3(3)	5(2)	5(1)	6(2)	3(3)	5(2)	5(0)
	Early Reloc	5(1)	1(-2)	2(-2)	3(3)	4(2)	4(1)	2(3)	3(3)	4(2)	8(-1)
	Late Reloc	2(2)	2(0)	1(0)	--	1(3)	6(2)	3(3)	6(3)	1(3)	9(0)
4. Delayed cancer fatalities (excluding thyroid) (persons)	Evac-Reloc	6(2)	1(1)	4(1)	6(3)	2(3)	1(3)	4(3)	4(3)	2(3)	2(1)
	Early Reloc	6(2)	3(1)	5(1)	6(3)	2(3)	1(3)	4(3)	4(3)	2(3)	3(1)
	Late Reloc	7(2)	3(1)	5(1)	--	2(3)	1(3)	4(3)	4(3)	2(3)	3(1)
5. Delayed thyroid cancer fatalities (persons)	Evac-Reloc	1(2)	2(1)	2(1)	8(2)	6(2)	2(2)	1(3)	9(2)	6(2)	1(1)
	Early Reloc	1(2)	2(1)	2(1)	8(2)	6(2)	2(2)	1(3)	1(3)	6(2)	2(1)
	Late Reloc	2(2)	2(1)	2(1)	--	7(2)	2(2)	1(3)	1(3)	7(2)	2(1)
6. Total person-rems	Evac-Reloc	1(7)	5(5)	8(5)	4(7)	2(7)	2(7)	6(7)	6(7)	2(7)	4(5)
	Early Reloc	1(7)	5(5)	9(5)	4(7)	2(7)	2(7)	6(7)	6(7)	2(7)	5(5)
	Late Reloc	1(7)	5(5)	1(6)	--	2(7)	3(7)	7(7)	7(7)	3(7)	6(5)
7. Cost of offsite mitigation measures (1980 dollars)	Evac-Reloc	3(8)	5(7)	6(7)	2(9)	1(9)	1(9)	4(9)	3(9)	1(9)	1(6)
	Early Reloc	2(8)	2(6)	3(6)	2(9)	1(9)	1(9)	4(9)	3(9)	1(9)	1(6)
	Late Reloc	2(8)	2(6)	3(6)	--	1(9)	1(9)	4(9)	3(9)	1(9)	1(6)
8. Land area for long-term interdiction (m^2)	Evac-Reloc	1(6)	2(4)	3(4)	7(7)	2(7)	3(7)	1(8)	6(7)	2(7)	0
	Early Reloc	1(6)	2(4)	3(4)	7(7)	2(7)	3(7)	1(8)	6(7)	2(7)	0
	Late Reloc	1(6)	2(4)	3(4)	--	2(7)	3(7)	1(8)	6(7)	2(7)	0

*This release category has a probability less than 10^{-9} per reactor-year to be initiated by severe earthquakes; it is not analyzed with Late Reloc mode for its insignificant contribution to risks due to its low probability.

**2(2) = 2 x 10^2 = 200.

***These release categories are initiated by plant internal causes; therefore, the Late Reloc mode does not apply.

NOTE: Please see Section 5.9.4.5(7) for discussion of uncertainties. Estimated numbers were rounded to one significant digit only for the purpose of this table.

Table K.1 (Continued)

Consequence Category	Offsite Emergency Response Mode	Release Categories									
		III-T/$\overline{\text{LGT}}$	IV-T/DW	IV-T/WW	IV-T/$\overline{\text{WW}}$	I-S/DW***	IV-A/DW***	IS-C/DW	IS-$\overline{\text{C}}$/DW	S-H2O/$\overline{\text{WW}}$	S-$\overline{\text{H2O}}$/$\overline{\text{WW}}$
1. Early fatalities with supportive medical treatment (persons)	Evac-Reloc	6(-1)	6(2)	5(2)	6(2)	0	7(2)	3(2)	1(2)	0	0
	Early Reloc	1(0)	1(3)	1(3)	1(3)	0	1(3)	7(2)	7(2)	2(2)	6(2)
	Late Reloc	7(1)	4(3)	4(3)	4(3)	--	--	3(3)	3(3)	2(3)	3(3)
2. Population receiving in excess of 200 Rems total marrow dose from early exposure (persons)	Evac-Reloc	5(1)	5(3)	4(3)	4(3)	0	4(3)	2(3)	2(3)	4(2)	4(2)
	Early Reloc	3(1)	6(3)	5(3)	4(3)	5(-1)	5(3)	3(3)	3(3)	1(3)	2(3)
	Late Reloc	1(3)	1(4)	1(4)	1(4)	--	--	9(3)	9(3)	5(3)	8(3)
3. Early injuries (persons)	Evac-Reloc	6(1)	5(3)	4(3)	3(3)	0	3(3)	2(3)	2(3)	5(2)	6(2)
	Early Reloc	4(1)	5(3)	4(3)	4(3)	5(-1)	3(3)	3(3)	3(3)	2(3)	2(3)
	Late Reloc	7(2)	7(3)	6(3)	7(3)	--	--	6(3)	6(3)	3(3)	5(3)
4. Delayed cancer fatalities (excluding thyroid) (persons)	Evac-Reloc	1(3)	5(3)	5(3)	5(3)	2(2)	5(3)	4(3)	4(3)	3(3)	4(3)
	Early Reloc	1(3)	5(3)	5(3)	5(3)	2(2)	5(3)	4(3)	4(3)	3(3)	4(3)
	Late Reloc	1(3)	6(3)	6(3)	6(3)	--	--	4(3)	4(3)	3(3)	4(3)
5. Delayed thyroid cancer fatalities (persons)	Evac-Reloc	2(2)	2(3)	2(3)	2(3)	3(1)	2(3)	9(2)	9(2)	7(2)	1(3)
	Early Reloc	2(2)	2(3)	2(3)	2(3)	3(1)	2(3)	9(2)	1(3)	8(2)	1(3)
	Late Reloc	2(2)	2(3)	2(3)	2(3)	--	--	1(3)	1(3)	8(2)	1(3)
6. Total person-rems	Evac-Reloc	2(7)	8(7)	7(7)	8(7)	3(6)	8(7)	5(7)	5(7)	4(7)	6(7)
	Early Reloc	2(7)	8(7)	8(7)	8(7)	3(6)	8(7)	5(7)	5(7)	5(7)	6(7)
	Late Reloc	3(7)	9(7)	8(7)	9(8)	--	--	6(7)	6(7)	5(7)	7(7)
7. Cost of offsite mitigation measures (1980 dollars)	Evac-Reloc	1(9)	5(9)	5(9)	5(9)	9(7)	5(9)	2(9)	2(9)	2(9)	3(9)
	Early Reloc	1(9)	5(9)	5(9)	5(9)	4(7)	5(9)	2(9)	2(9)	2(9)	3(9)
	Late Reloc	1(9)	5(9)	5(9)	5(9)	--	--	2(9)	2(9)	2(9)	3(9)
8. Land area for long-term interdiction (m^2)	Evac-Reloc	3(7)	1(8)	1(8)	2(8)	3(5)	1(8)	5(7)	6(7)	5(7)	8(7)
	Early Reloc	3(7)	1(8)	1(8)	2(8)	3(5)	1(8)	5(7)	6(7)	5(7)	8(7)
	Late Reloc	3(7)	1(8)	1(8)	2)8)	--	--	5(7)	6(7)	5(7)	8(7)

APPENDIX L

CONSEQUENCES AND RISKS OF RELEASE CATEGORIES INITIATED BY SEVERE EARTHQUAKES AND THOSE OF RELEASE CATEGORIES INITIATED BY OTHER CAUSES

APPENDIX L

CONSEQUENCES AND RISKS OF RELEASE CATEGORIES INITIATED BY SEVERE EARTHQUAKES AND THOSE OF RELEASE CATEGORIES INITIATED BY OTHER CAUSES

Probability distributions of accident consequences and probability-weighted values of these consequences (i.e., risks) are presented and discussed in Sections 5.9.4.5(3), 5.9.4.5(4), and 5.9.4.5(6). The results presented in those sections were the combined results from release categories initiated by internal causes, fires and low to moderately severe earthquakes, and from release categories initiated by severe earthquakes. The severe earthquake initiated release categories were analyzed with the assumption of late relocation (Late Reloc) mode of offsite emergency response (see Section 5.9.4.5(2) and Table 5.11f). Release categories initiated by causes other than severe earthquakes were analyzed with the assumption of evacuation and relocation (Evac-Reloc) mode of offsite emergency response (see Section 5.9.4.5(2) and Table 5.11f). A separate display of radiological contributions to the overall results (presented in sections cited above) from release categories initiated by severe earthquakes and from release categories initiated by causes other than severe earthquakes is provided here. Additionally, breakdowns of societal consequences of early fatalities and latent cancer fatalities in terms of contributions from spatial intervals up to 50 miles (80 km) from the Limerick reactors are also presented.

Figures L.1 through L.20 display the breakdowns of each of the graphical plots presented in Figures 5.4b through 5.4l in the sections cited above into two components--one ascribed to the severe earthquakes and the other ascribed to the other causes. In Figures L.1 through L.20, the graphical plots of Figures 5.4b through 5.4l are reproduced for easy reference.

Tables L.1a and b provide a breakdown of each category of risk shown in Table 5.11h into the two components as stated above. From these tables it is apparent that the release categories initiated by severe earthquakes are the dominant contributors to the risk of early fatality (with supportive or minimal medical treatment). These release categories contribute almost equally as the release categories initiated by other causes to the risk of early injury. However, the release categories initiated by causes other than severe earthquakes are the dominant contributors to the other types of risk in Tables L.1a and b.

Table L.2 shows the contributions to the risk of early fatality with supportive medical treatment from the spatial intervals within 50 miles (80 km) of the plant. Contributions from each spatial interval is also broken down into component contributions ascribed to severe earthquakes and the other causes.

Table L.3 shows similar results for early fatality as in Table L.2, but with minimal medical treatment.

Table L.4 shows the risk of latent cancer fatality in similar fashion as in Table L.2 for early fatality. Latent cancer fatality risks shown in Table L.4 include risks of both thyroid and nonthyroid cancer fatalities.

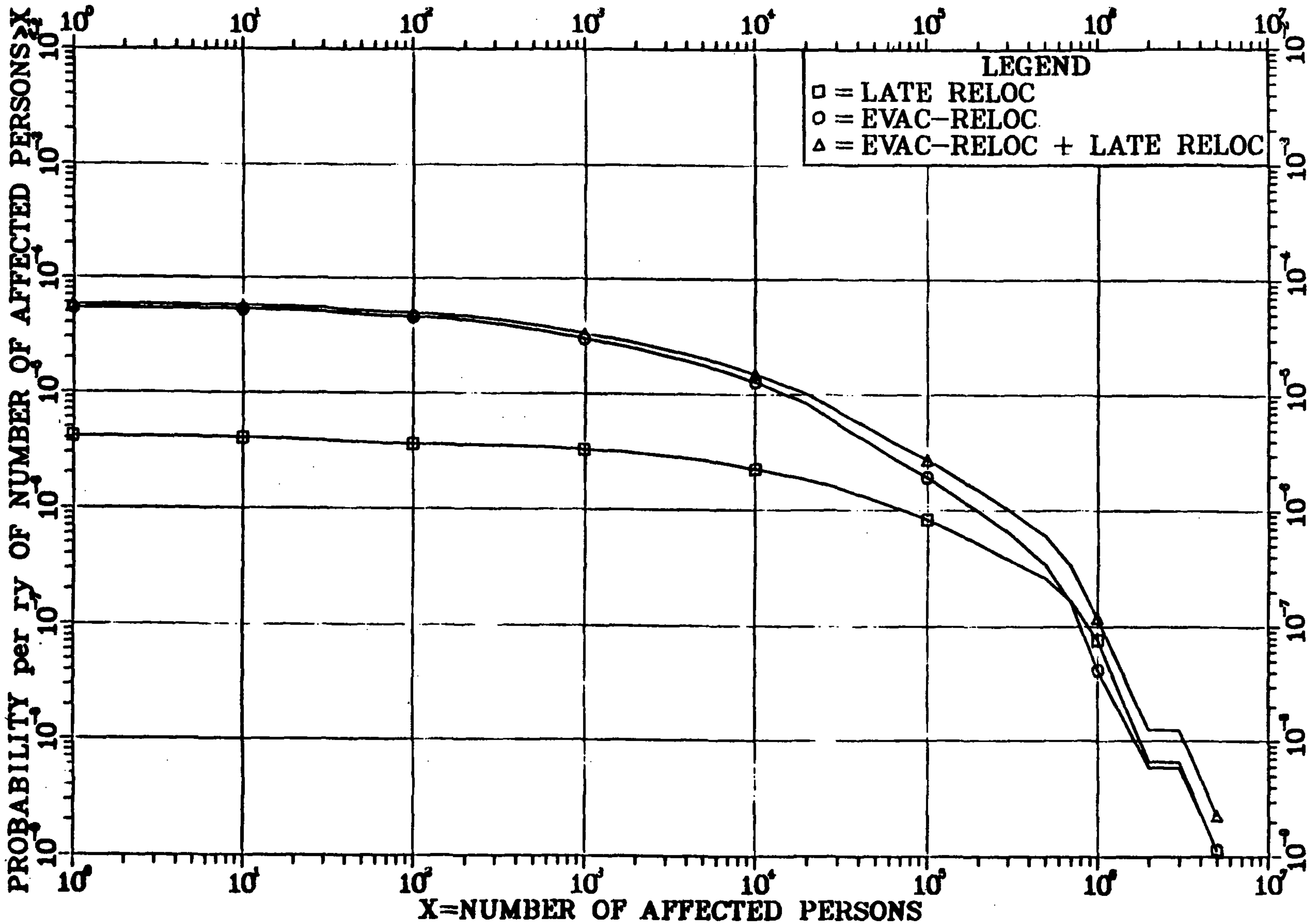

Figure L.1 Probability distribution of population with whole body dose greater than or equal to 25 rems

NOTE: Please see Section 5.9.4.5(7) for a discussion of uncertainty.

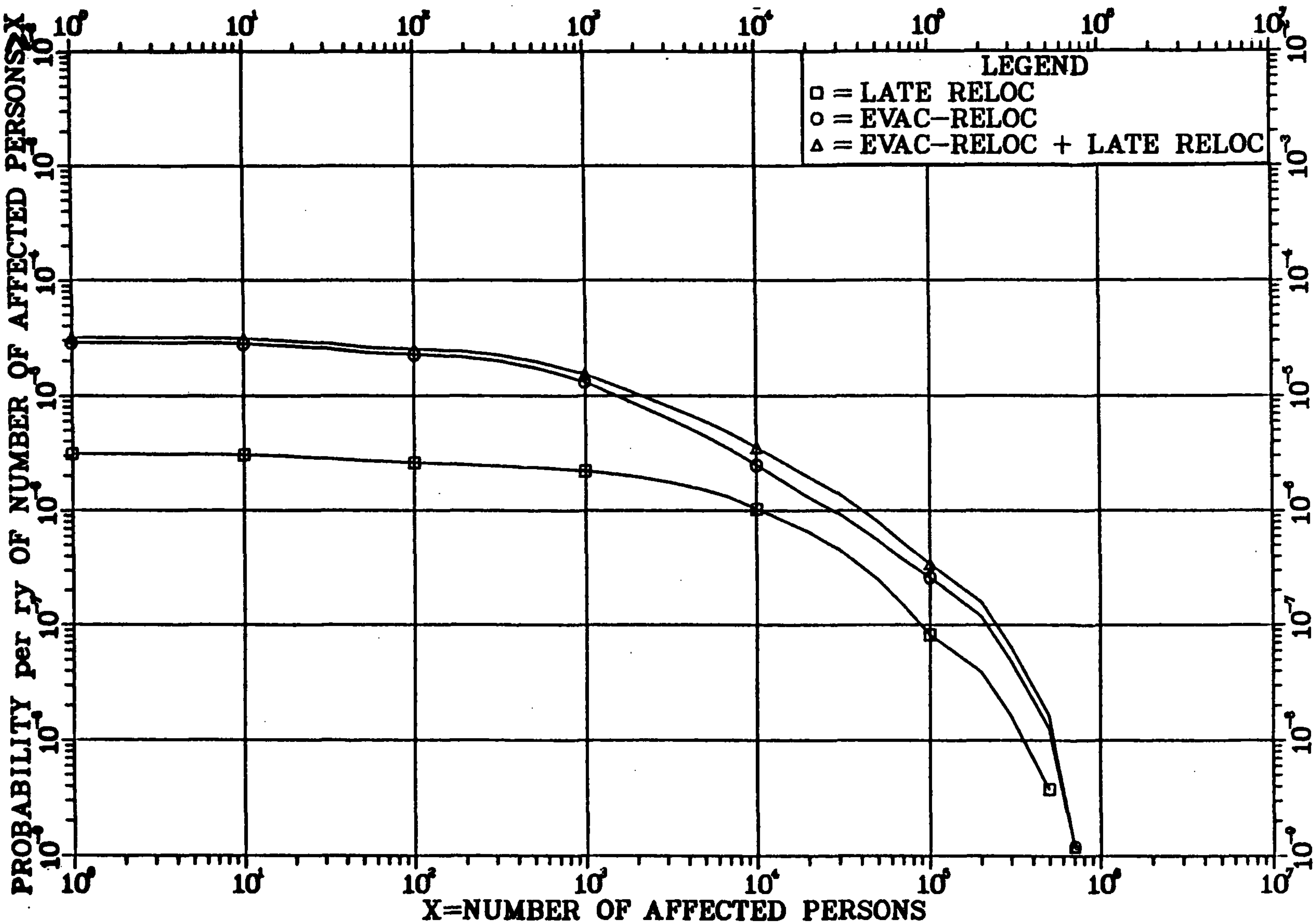

Figure L.2 Probability distribution of population with thyroid dose greater than or equal to 300 rems

NOTE: Please see Section 5.9.4.5(7) for a discussion of uncertainty.

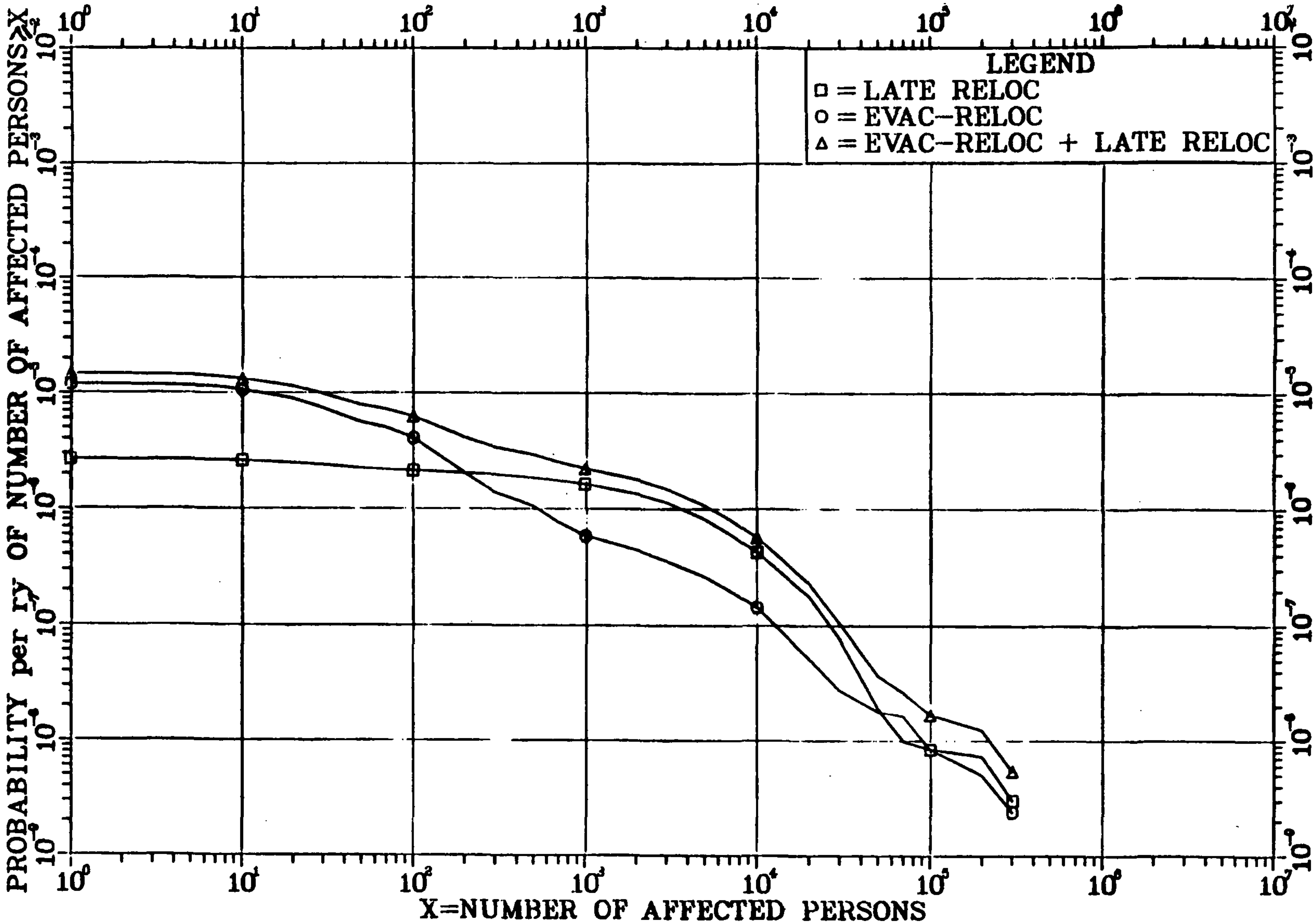

Figure L.3 Probability distribution of population with total bone marrow dose greater than or equal to 200 rems

NOTE: Please see Section 5.9.4.5(7) for a discussion of uncertainty.

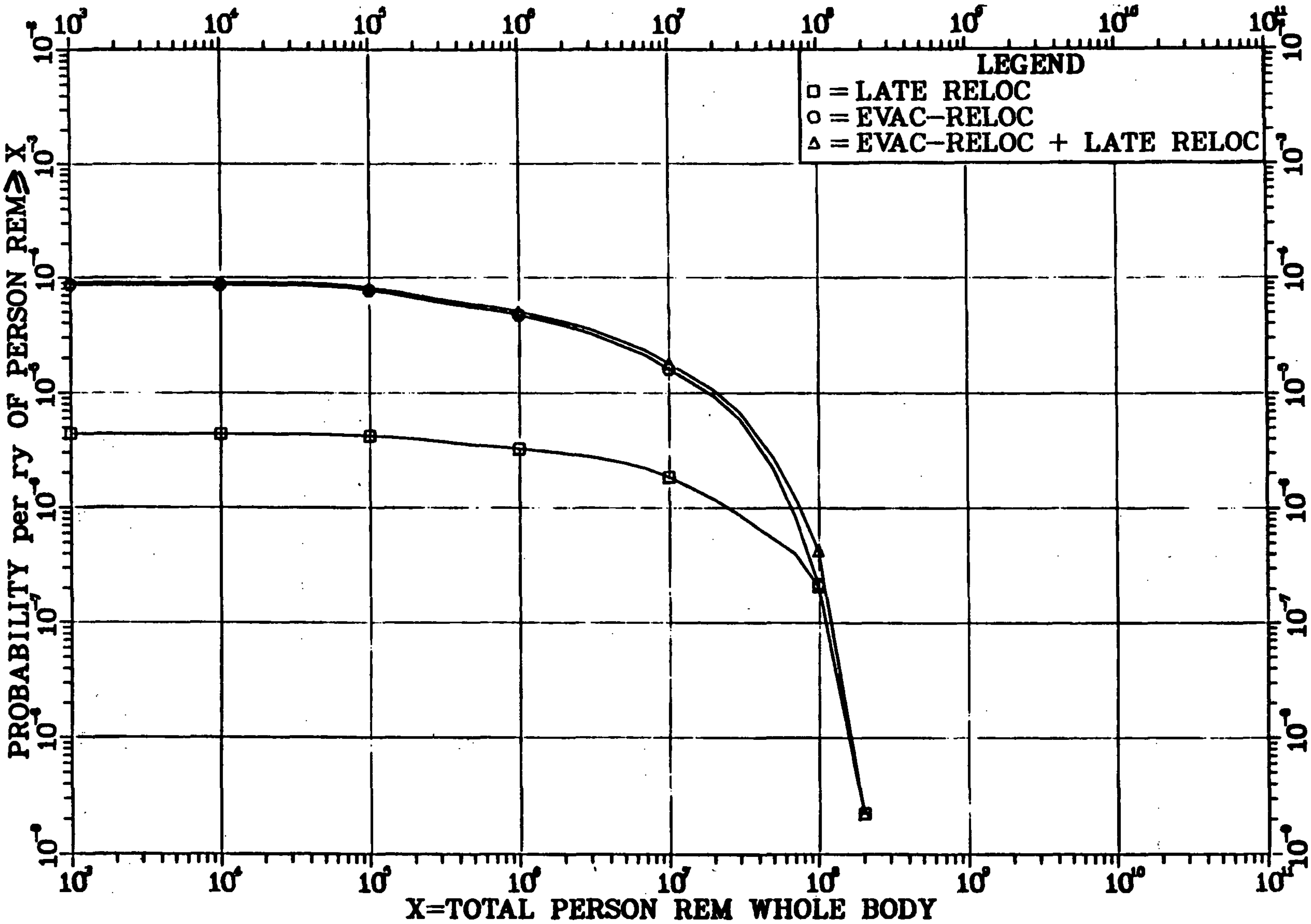

Figure L.4 Probability distribution of population exposure within 50 miles (80 km)

NOTE: Please see Section 5.9.4.5(7) for a discussion of uncertainty.

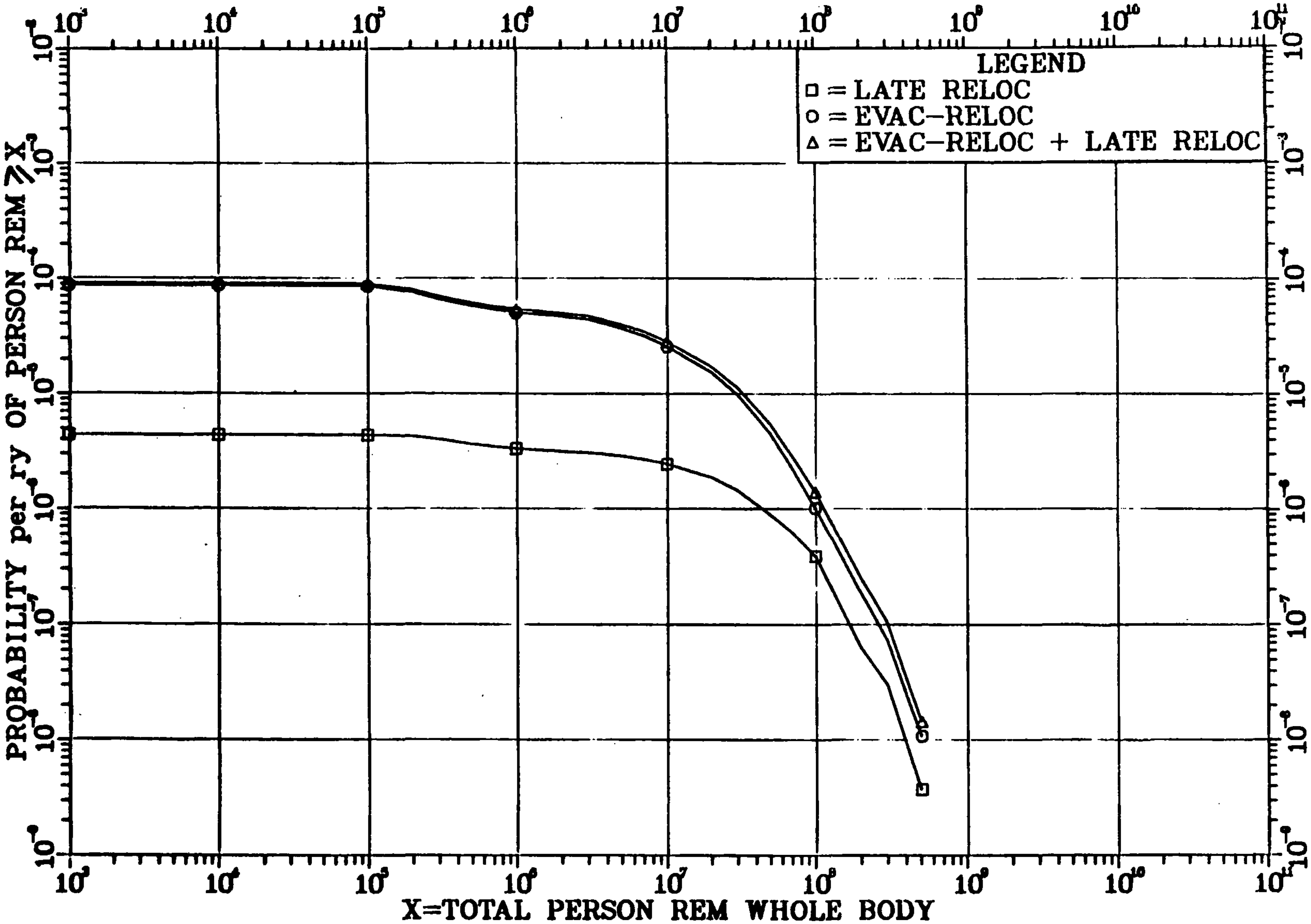

Figure L.5 Probability distribution of population exposure, entire region

NOTE: Please see Section 5.9.4.5(7) for a discussion of uncertainty.

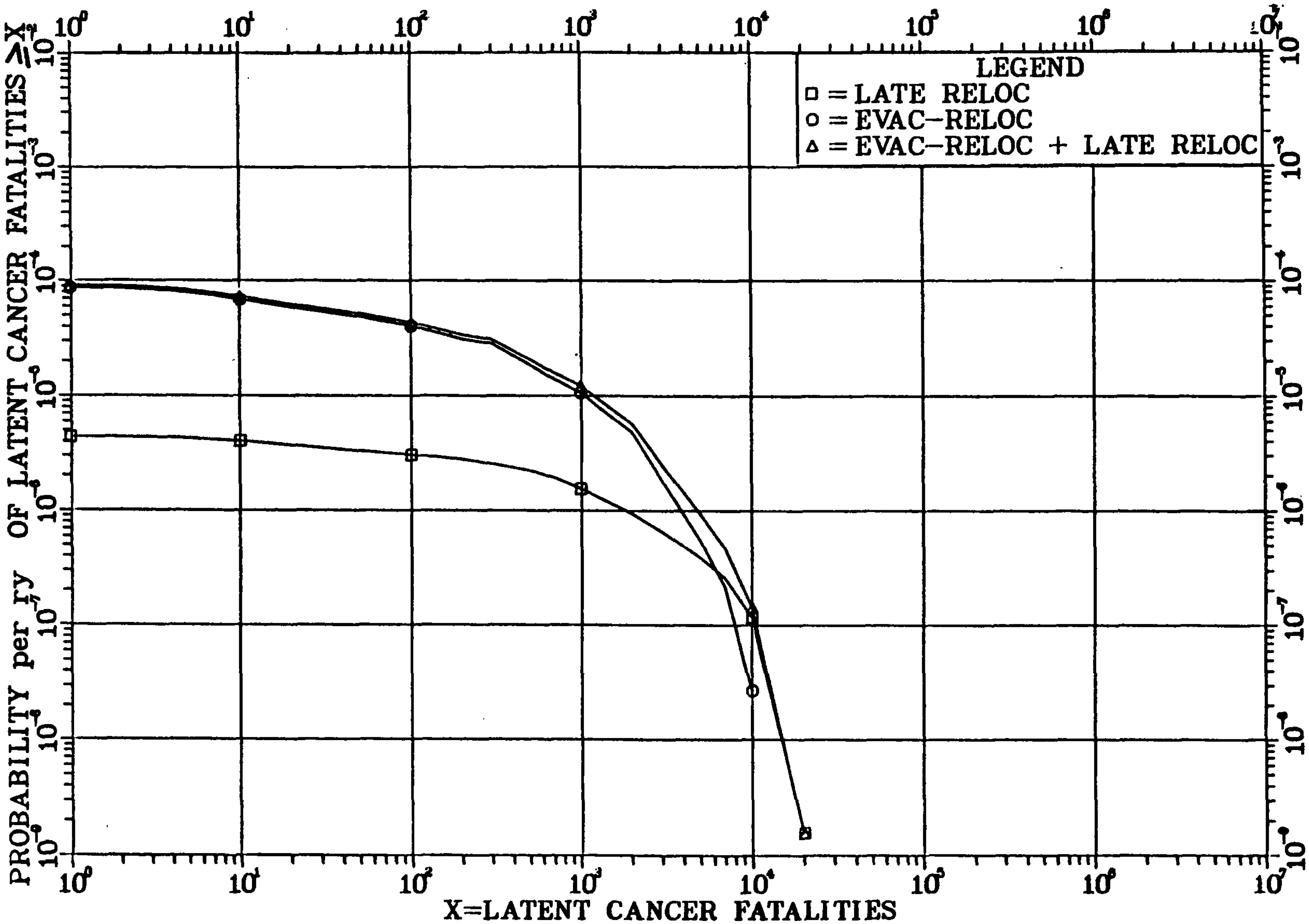

Figure L.6 Probability distribution of latent cancer fatalities, excluding thyroid within 50 miles (80 km)

NOTE: Please see Section 5.9.4.5(7) for a discussion of uncertainty.

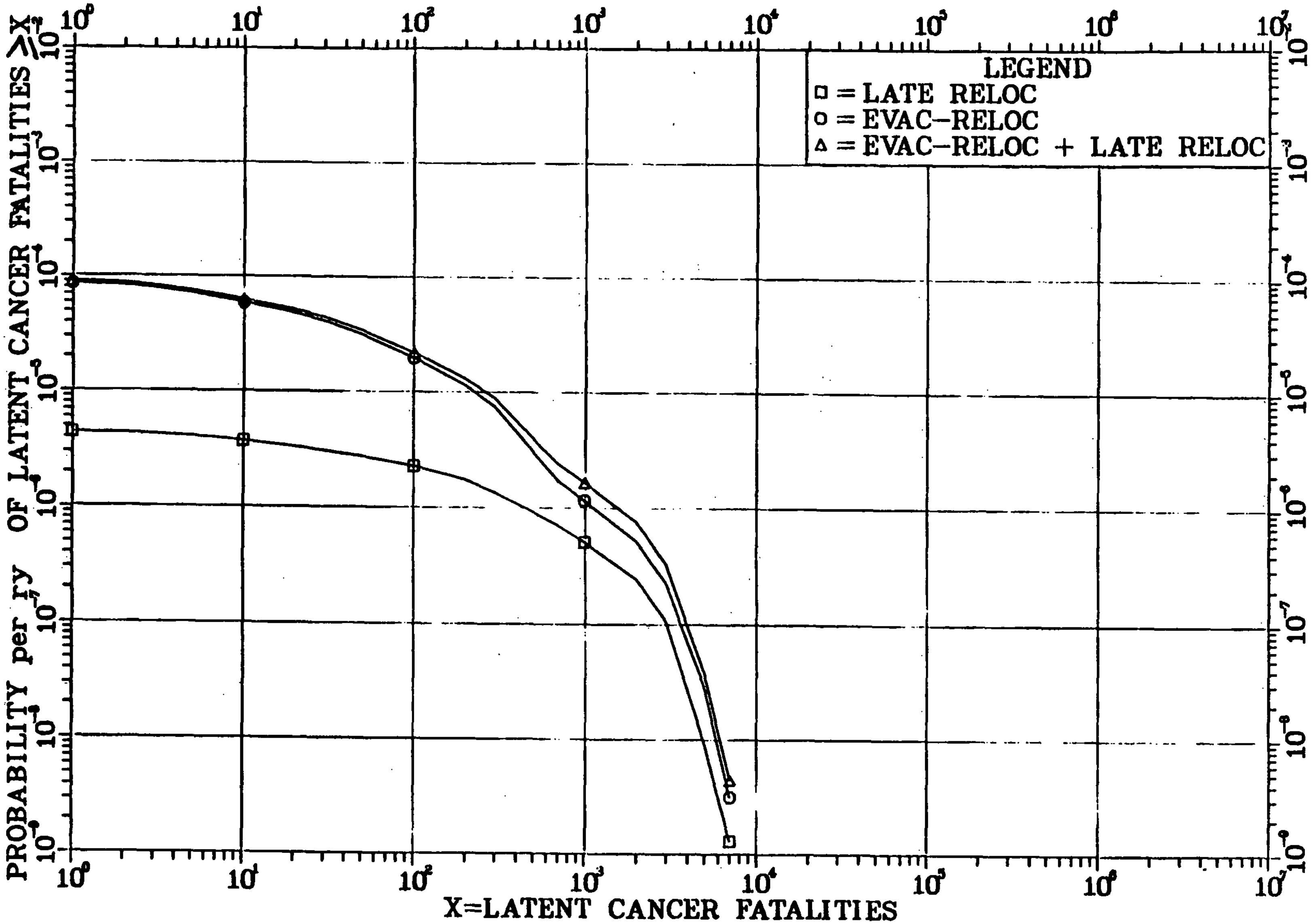

Figure L.7 Probability distribution of latent thyroid cancer fatalities, 50 miles (80 km)

NOTE: Please see Section 5.9.4.5(7) for a discussion of uncertainty.

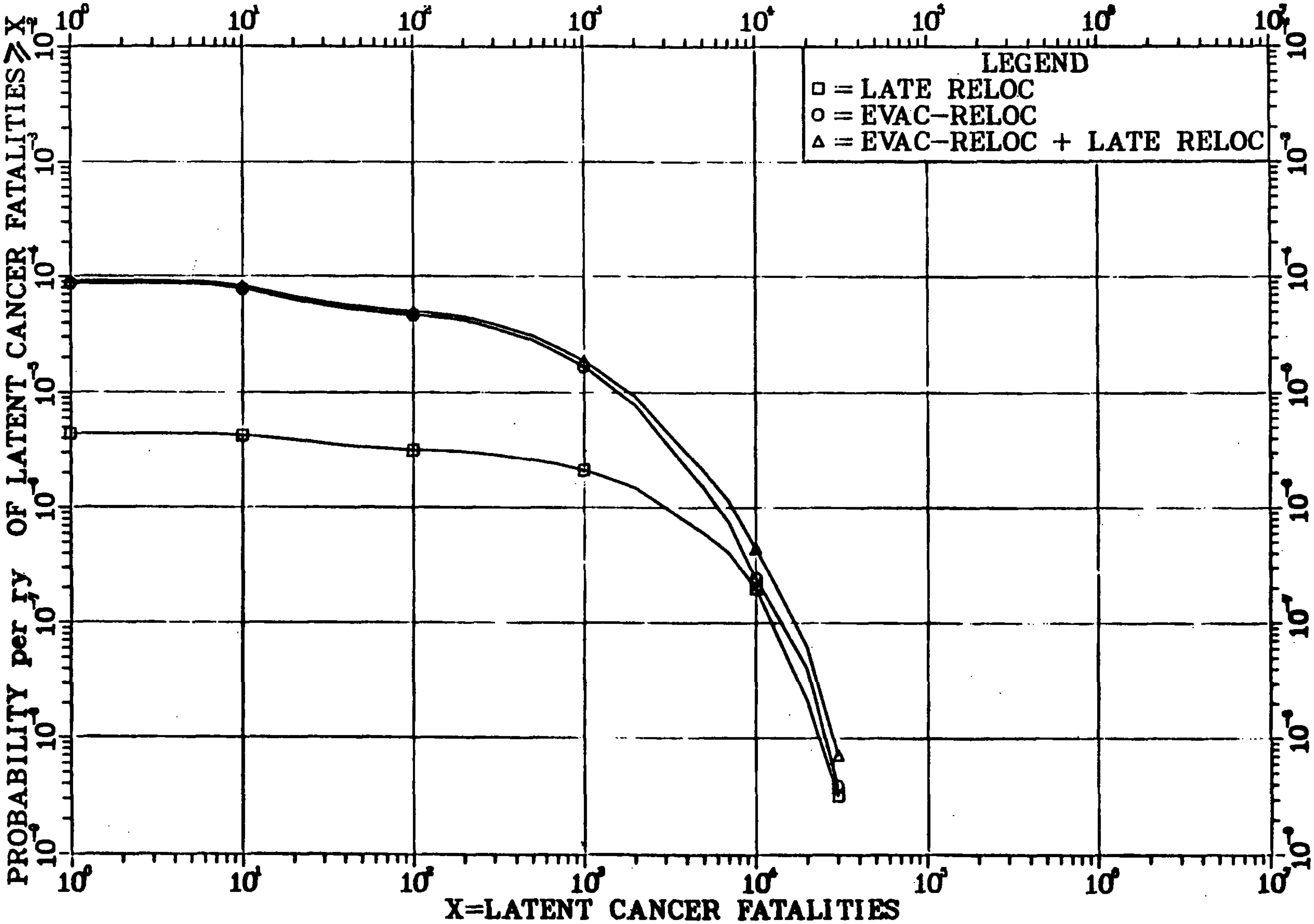

Figure L.8 Probability distribution of latent cancer fatalities, excluding thyroid, entire population

NOTE: Please see Section 5.9.4.5(7) for a discussion of uncertainty.

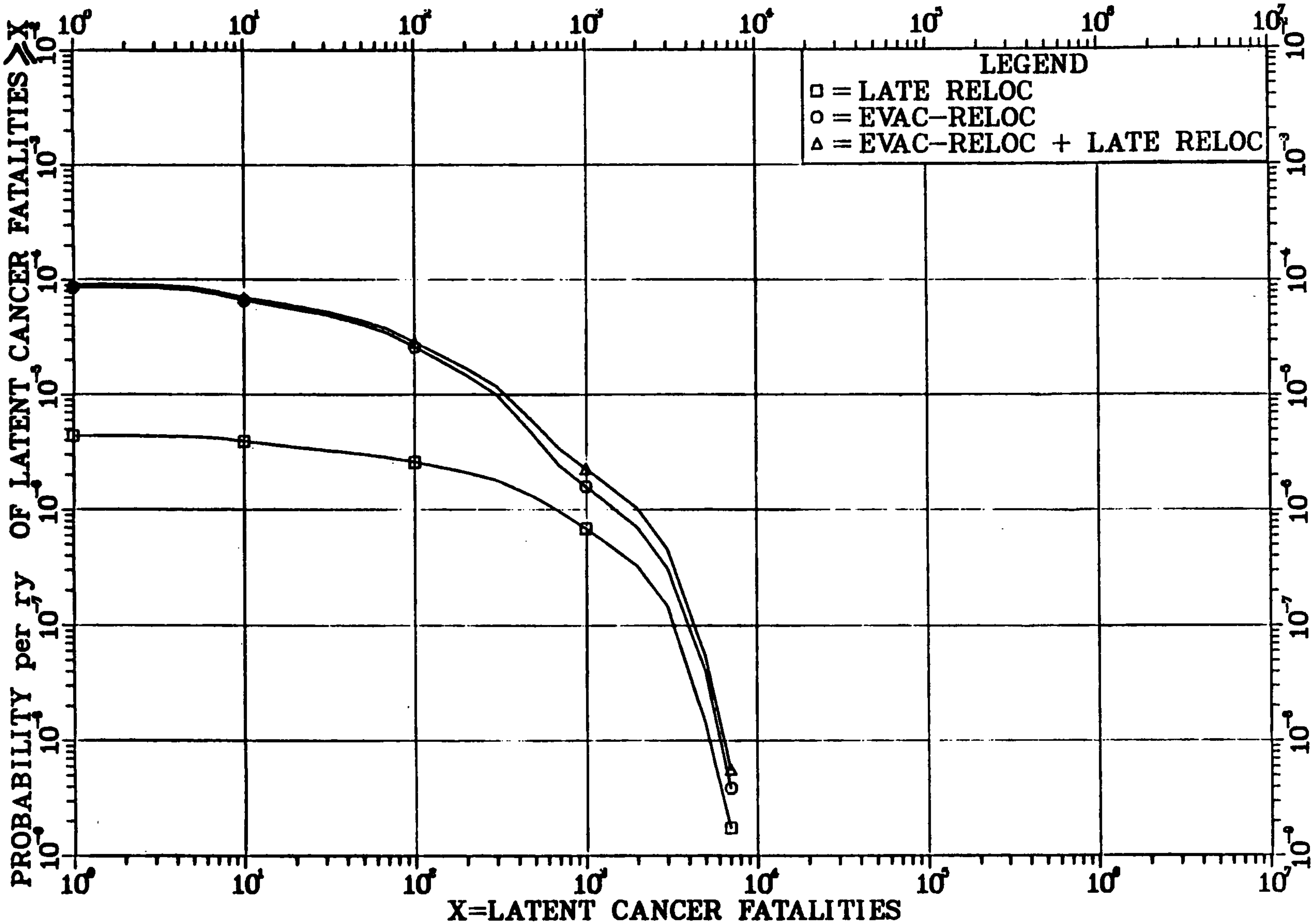

Figure L.9 Probability distribution of latent thyroid cancer fatality, entire population

NOTE: Please see Section 5.9.4.5(7) for a discussion of uncertainty.

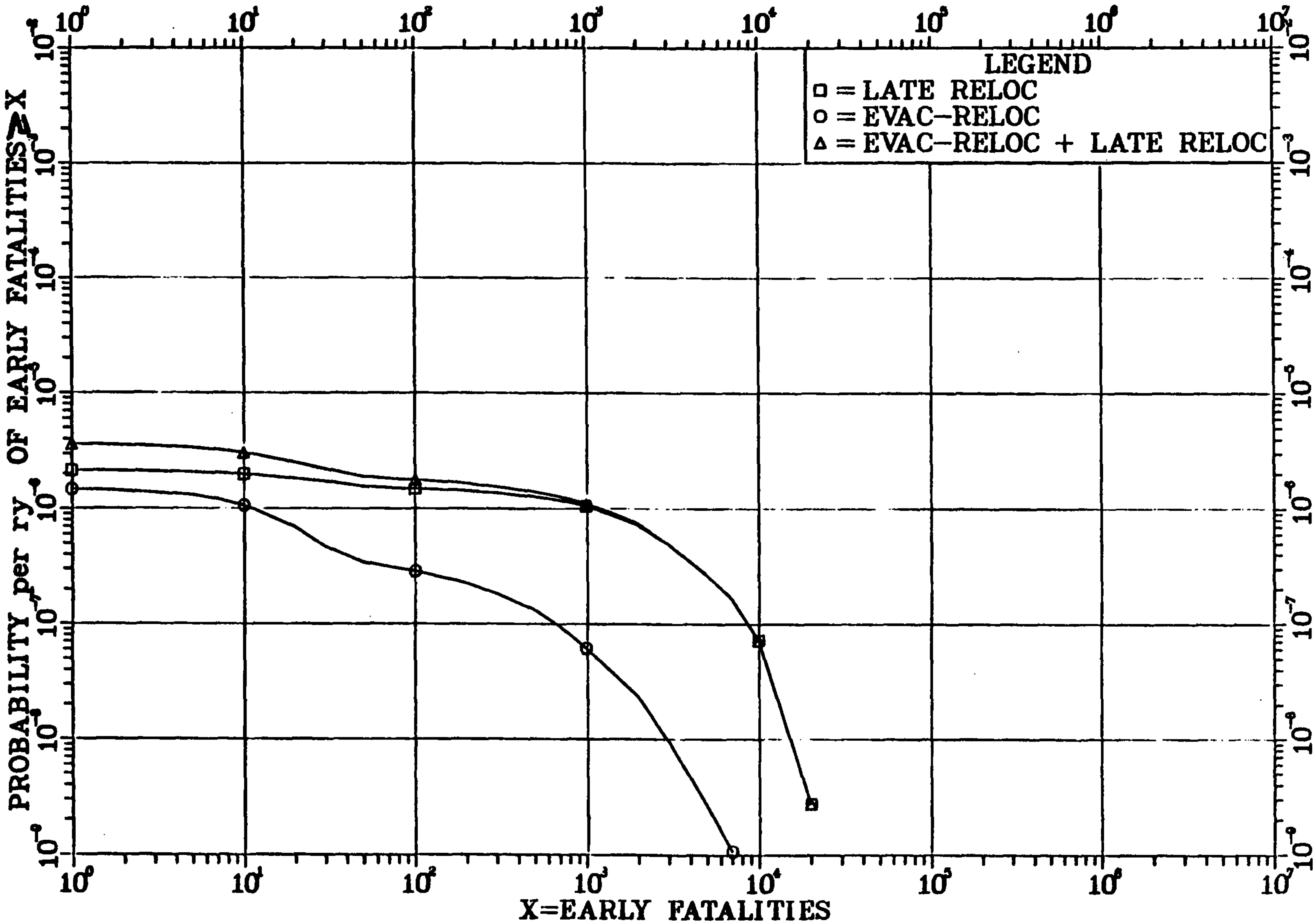

Figure L.10 Probability distribution of early fatality with supportive medical treatment

NOTE: Please see Section 5.9.4.5(7) for a discussion of uncertainty.

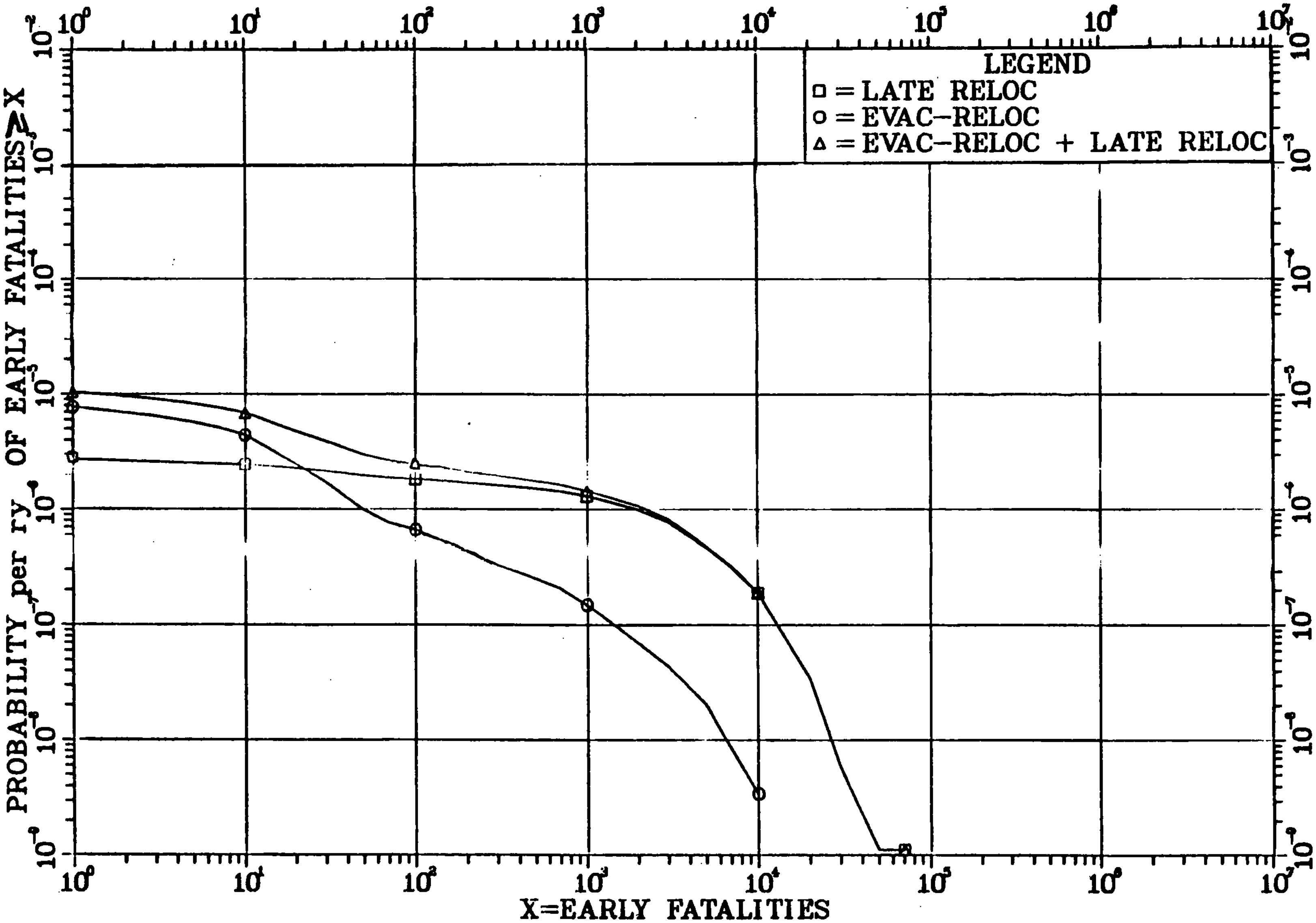

Figure L.11 Probability distribution of early fatalities with minimal medical treatment

NOTE: Please see Section 5.9.4.5(7) for a discussion of uncertainty.

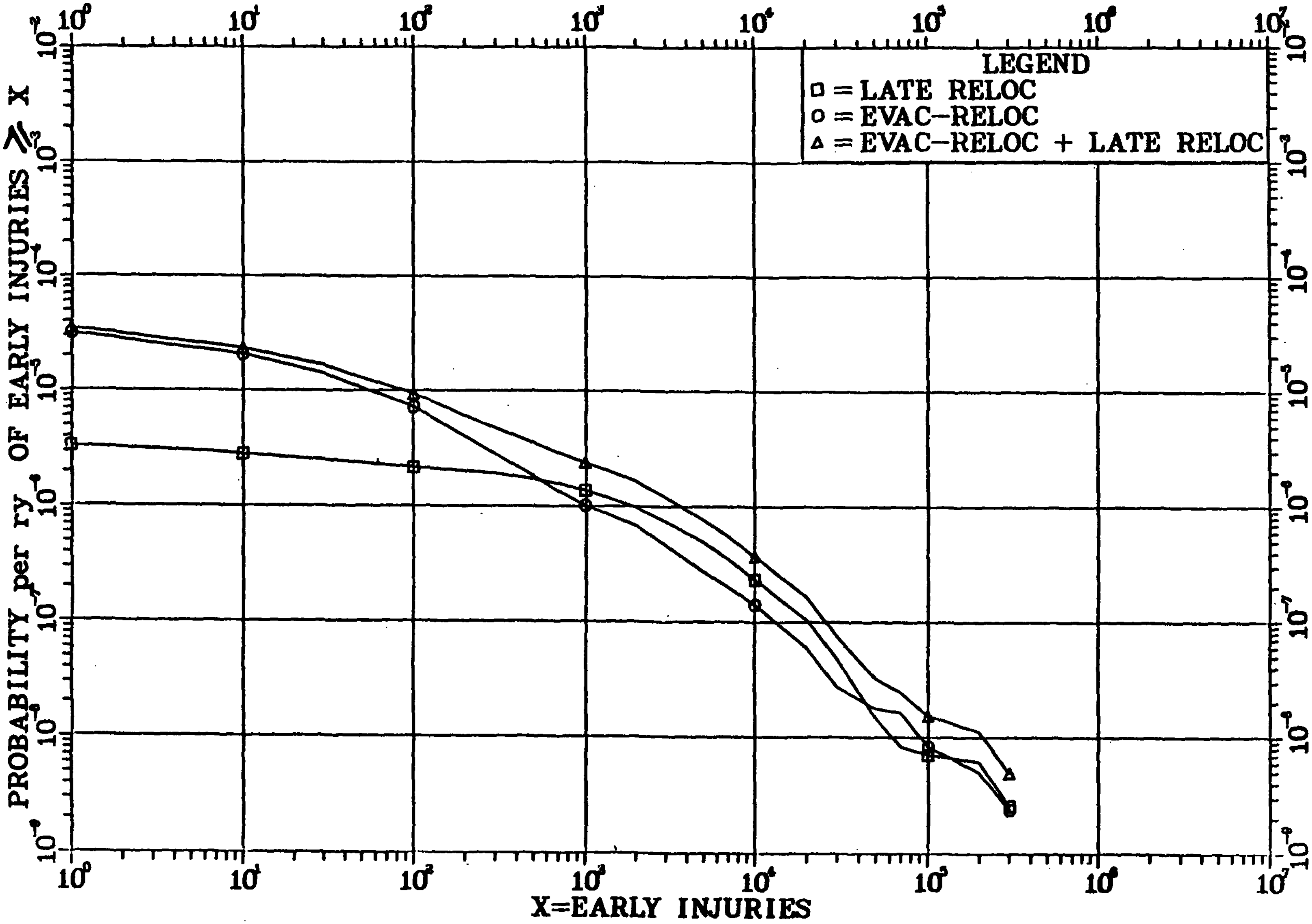

Figure L.12 Probability distribution of early injuries

NOTE: Please see Section 5.9.4.5(7) for a discussion of uncertainty.

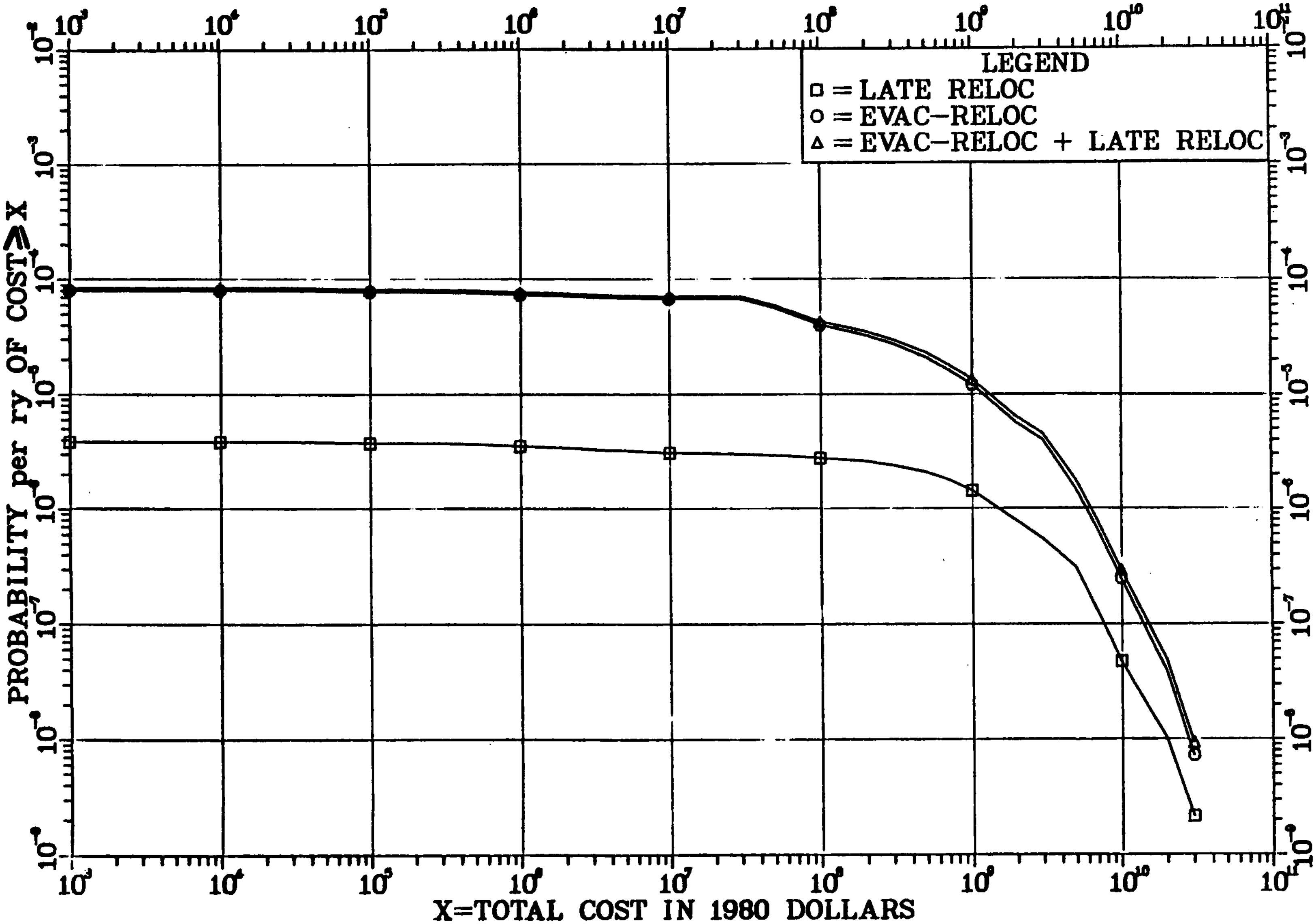

Figure L.13 Probability distribution of mitigation measures cost

NOTE: Please see Section 5.9.4.5(7) for a discussion of uncertainty.

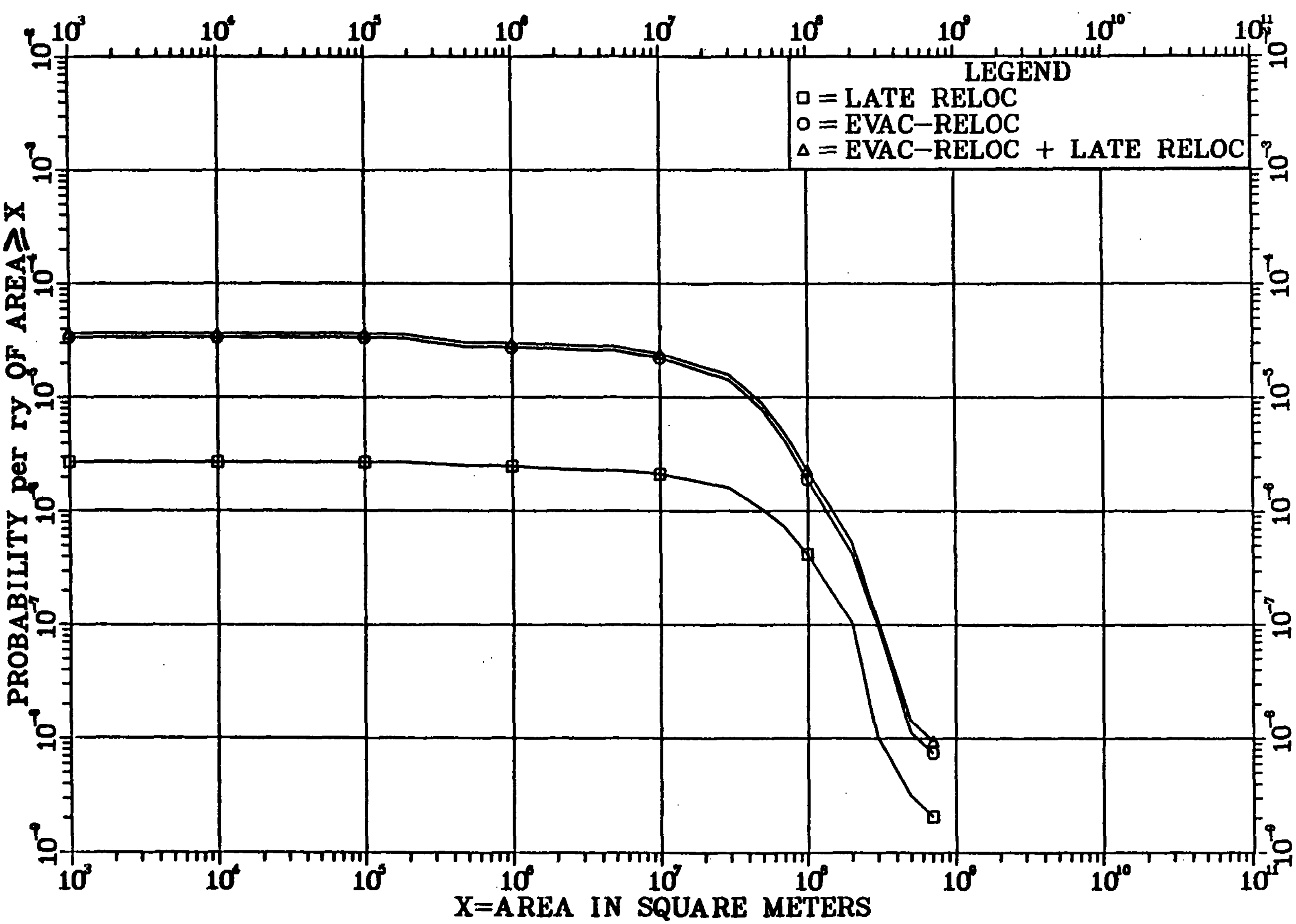

Figure L.14 Probability distribution of land area interdiction

NOTE: Please see Section 5.9.4.5(7) for a discussion of uncertainty.

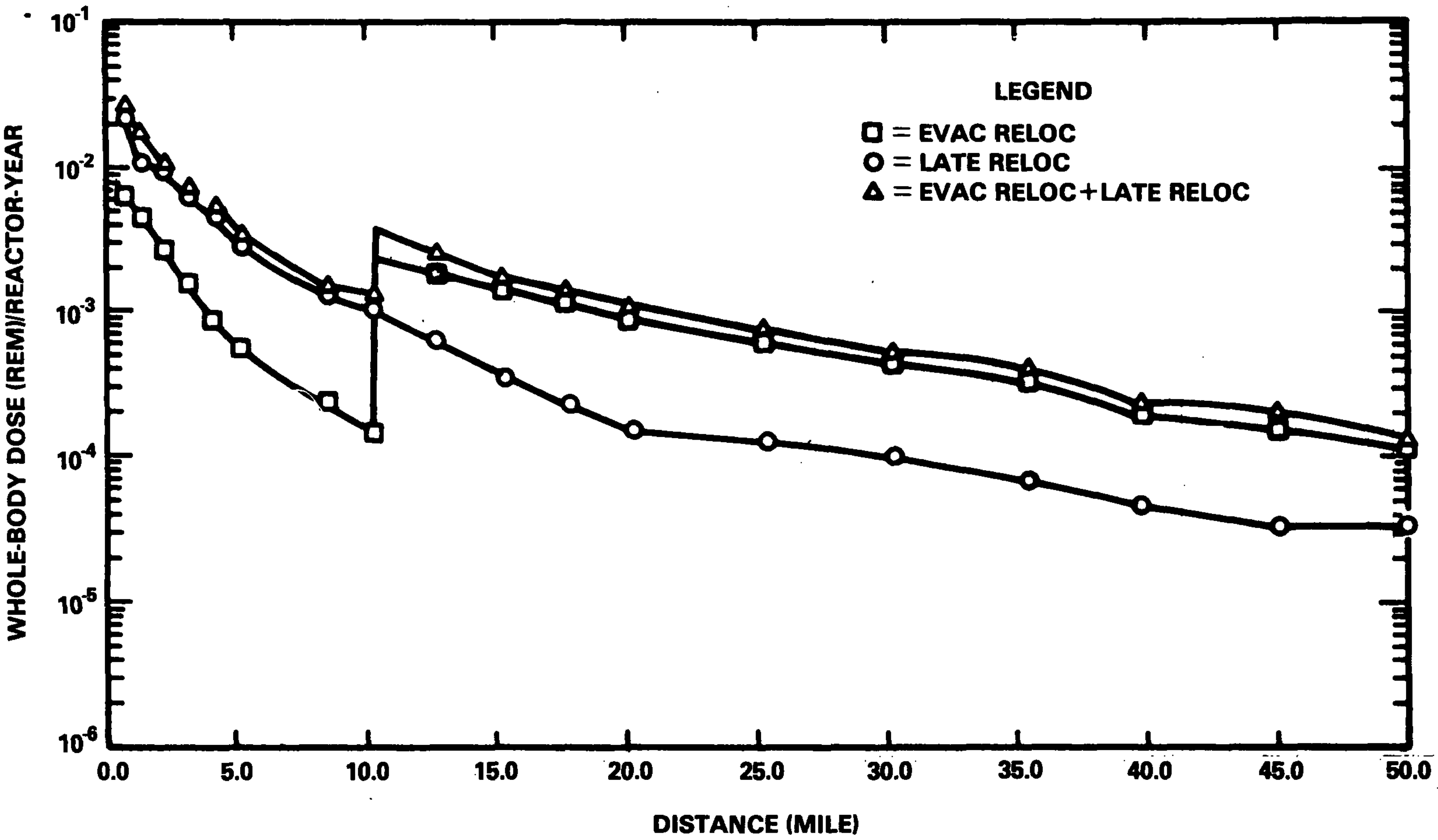

Figure L.15 Individual risk of downwind dose versus distance

NOTE: Please see Section 5.9.4.5(7) for discussion of uncertainties

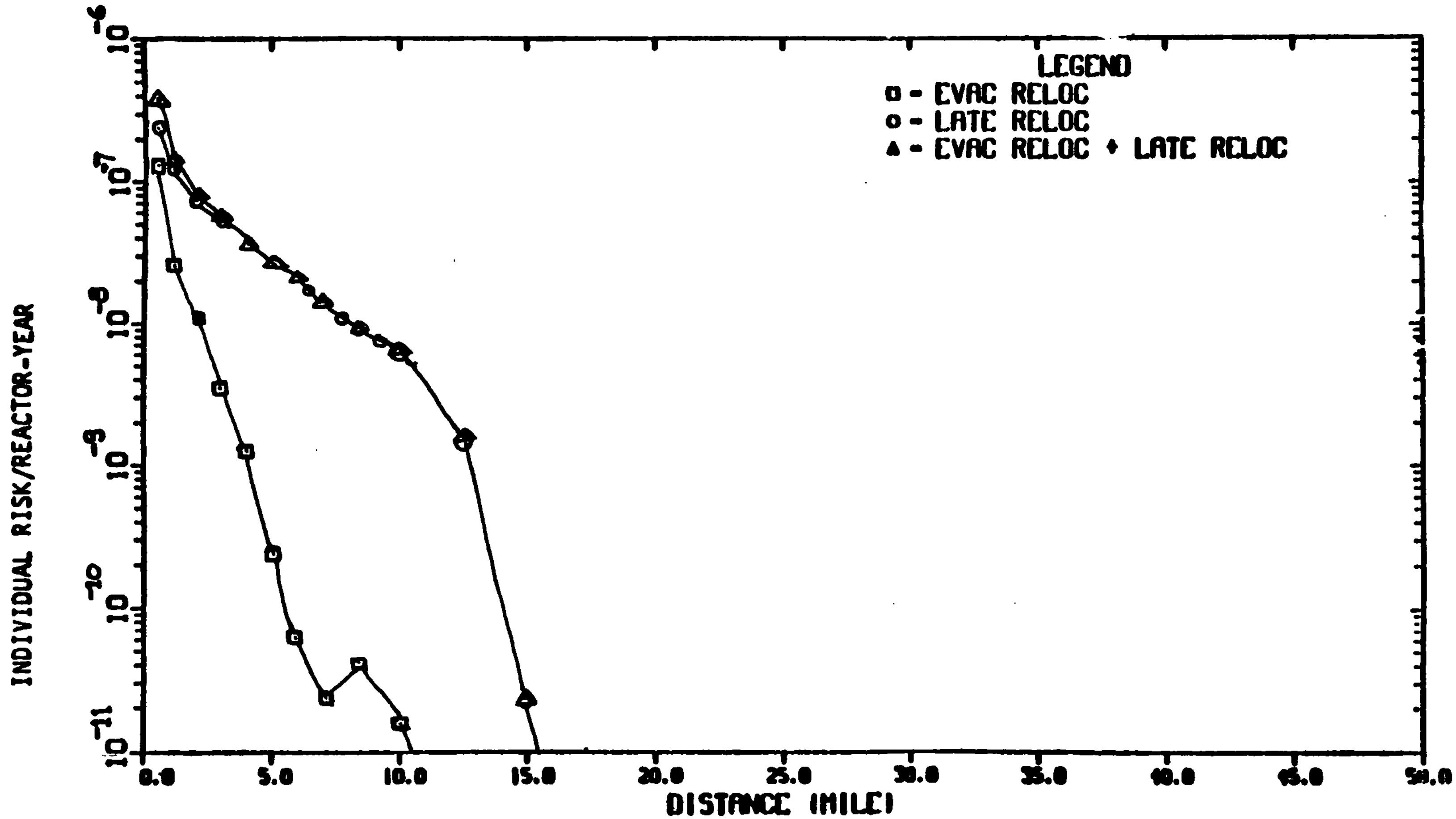

Figure L.16 Individual risk of early fatality with supportive medical treatment versus distance

NOTE: Please see Section 5.9.4.5(7) for discussion of uncertainties

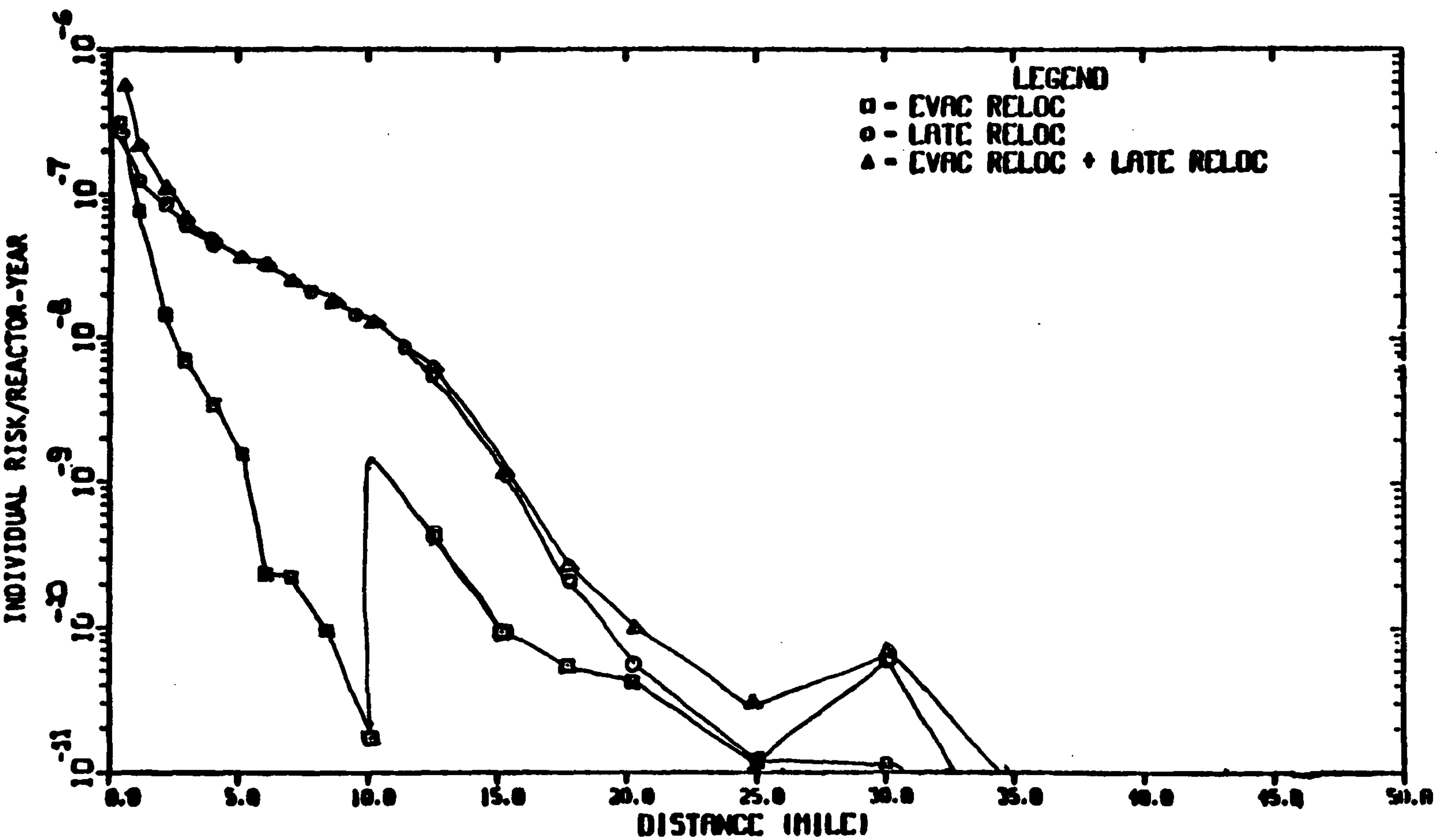

Figure L.17 Individual risk of early fatality with minimal medical treatment versus distance

NOTE: Please see Section 5.9.4.5(7) for discussion of uncertainties

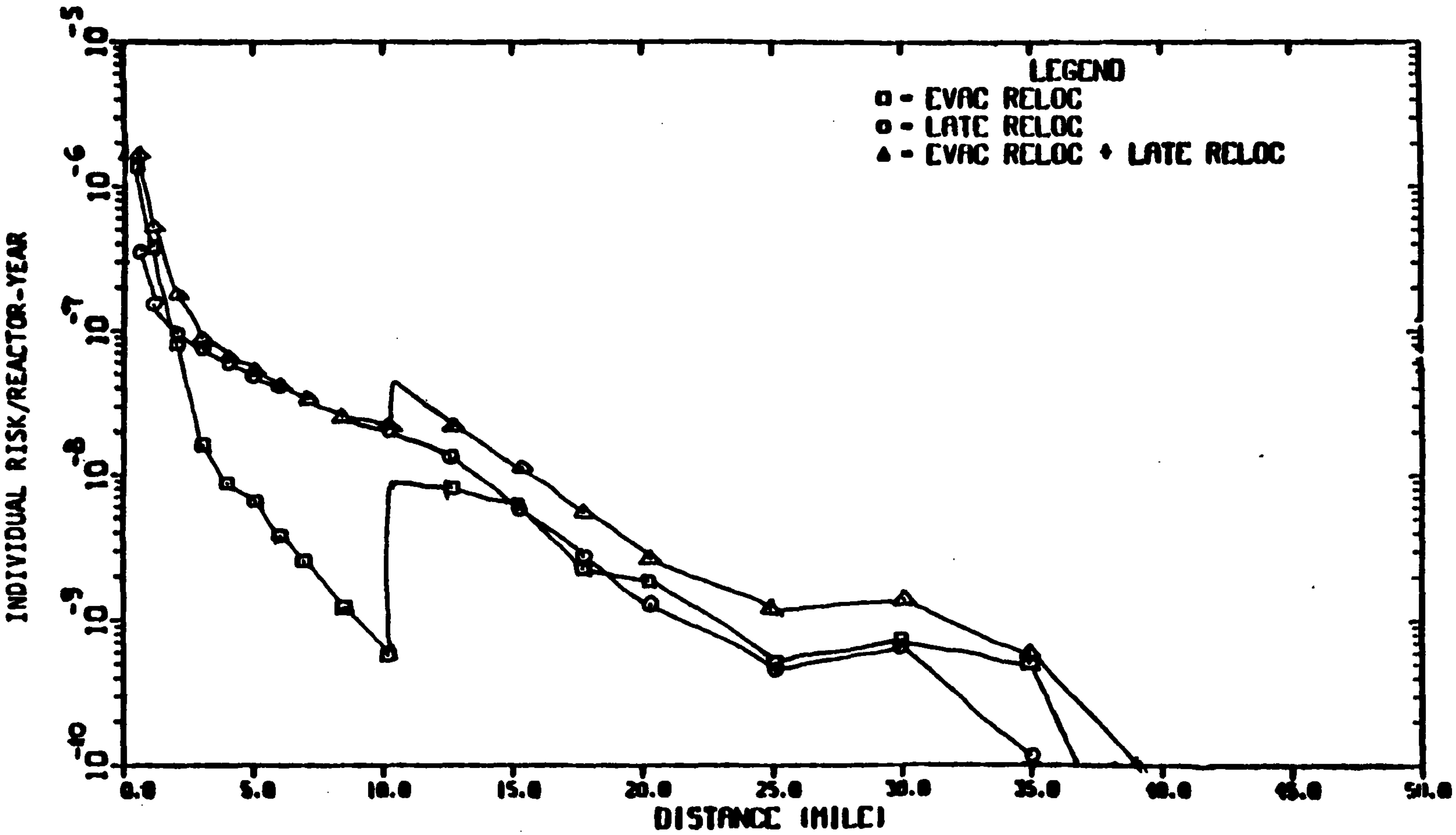

Figure L.18 Individual risk of early injury versus distance

NOTE: Please see Section 5.9.4.5(7) for discussion of uncertainties

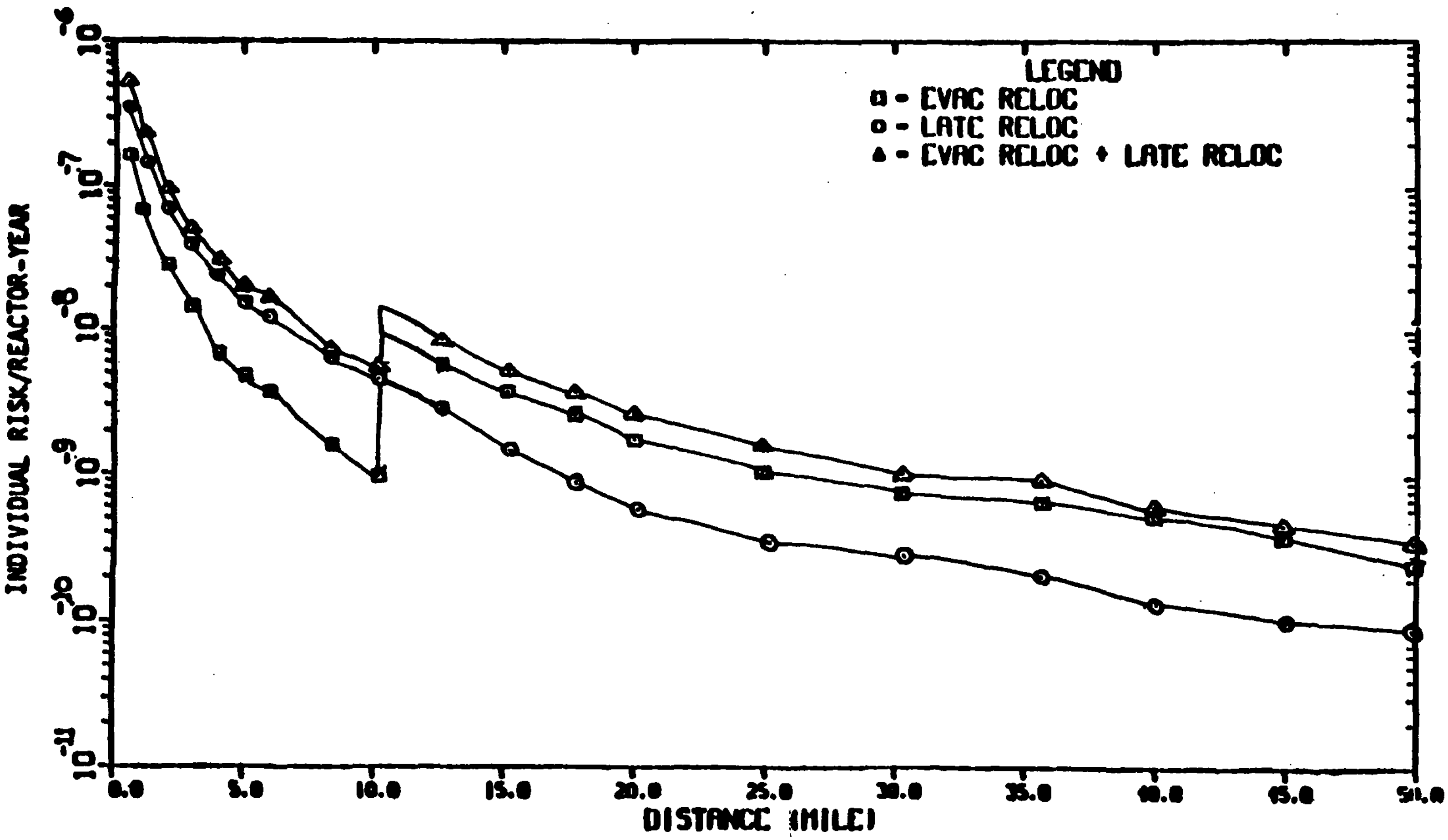

Figure L.19 Individual risk of latent cancer fatality (excluding thyroid) versus distance

NOTE: Please see Section 5.9.4.5(7) for discussion of uncertainties

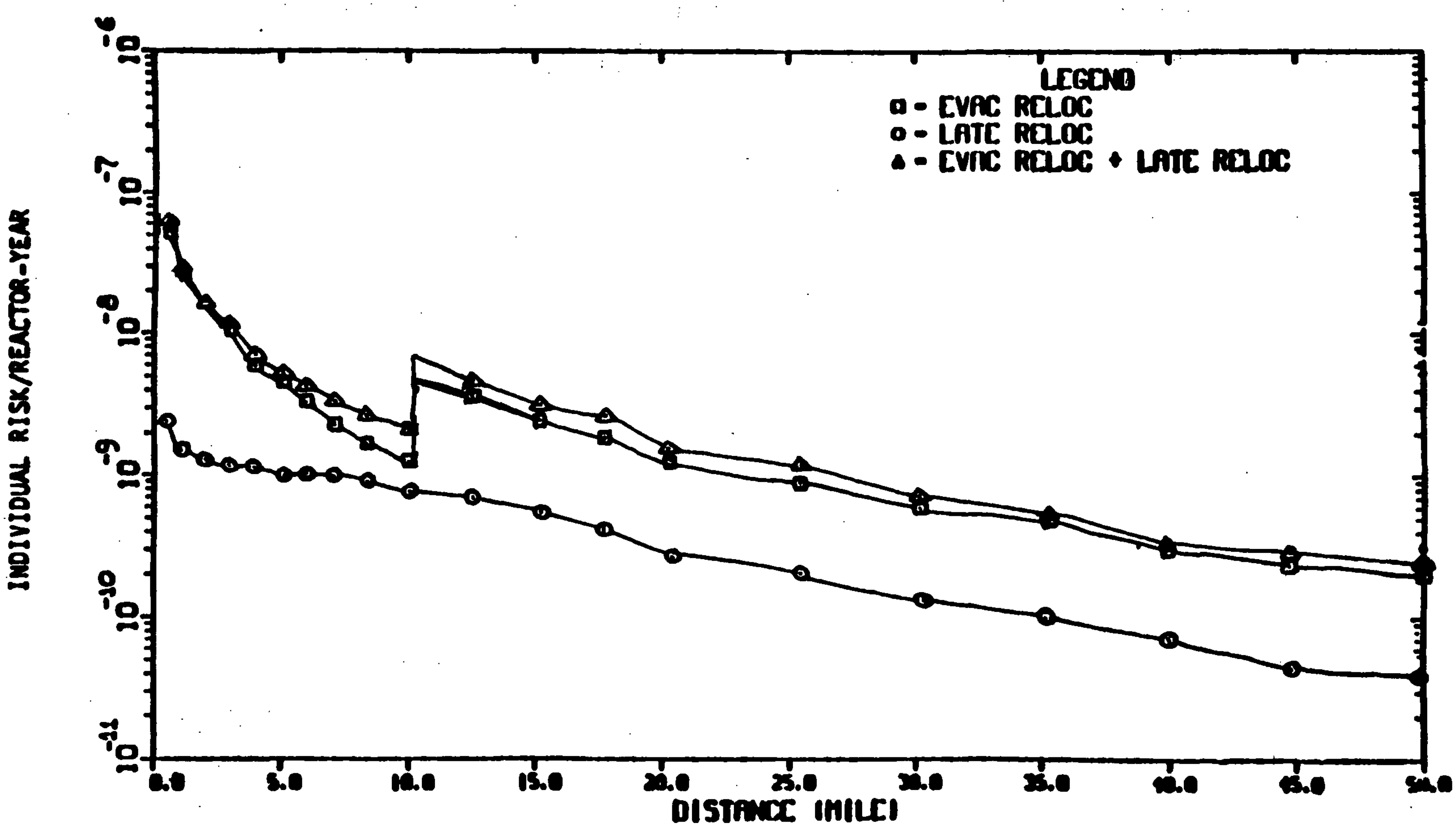

Figure L.20 Individual risk of latent thyroid cancer fatality versus distance

NOTE: Please see Section 5.9.4.5(7) for discussion of uncertainties

Table L.1a Societal risks within 50 miles (80 km) of Limerick site with Evac-Reloc* and Late Reloc* offsite emergency response modes

Consequence type	Risk per reactor-year: From causes other than severe earthquakes (Evac-Reloc)	From severe earthquakes (Late Reloc)	Total
1. Early fatalities with supportive medical treatment (persons)	2(-4)**	5(-3)	5(-3)
2. Early fatalities with minimal medical treatment (persons)	7(-4)	8(-3)	8(-3)
3. Early injuries (persons)	1(-2)	1(-2)	2(-2)
4. Latent cancer fatalities (excluding thyroid) (persons)	4(-2)	7(-3)	4(-2)
5. Latent thyroid cancer fatalities (persons)	9(-3)	2(-3)	1(-2)
6. Total person-rems	6(2)	9(1)	7(2)
7. Cost of offsite mitigation measures (1980 dollars)	4(4)	5(3)	5(4)
8. Land area for long-term interdiction (square meters)	1(3)	1(2)	1(3)

*See Section 5.9.4.5(2).
**2(-4) = 2 x 10^{-4} = .0002

NOTE: Please see Section 5.9.4.5(7) for discussion of uncertainties. Estimated numbers were rounded to one significant digit only for the purpose of this table.

Table L.1b Societal risks within the entire region of Limerick site with Evac-Reloc* and Late Reloc* offsite emergency response modes

Consequence type	Risk per reactor-year		
	From causes other than severe earthquakes (Evac-Reloc)	From severe earthquakes (Late Reloc)	Total
1. Early fatalities with supportive medical treatment (persons)	2(-4)**	5(-3)	5(-3)
2. Early fatalities with minimal medical treatment (persons)	7(-4)	8(-3)	8(-3)
3. Early injuries (persons)	1(-2)	1(-2)	2(-2)
4. Latent cancer fatalities (excluding thyroid) (persons)	6(-2)	1(-2)	7(-2)
5. Latent thyroid cancer fatalities (persons)	1(-2)	2(-3)	1(-2)
6. Total person-rems	1(3)	1(2)	1(3)
7. Cost of offsite mitigation measures (1980 dollars)	5(4)	6(3)	5(4)
8. Land area for long-term interdiction (square meters)	1(3)	2(2)	1(3)

*See Section 5.9.4.5(2).
**2(-4) = 2×10^{-4} = .0002

NOTE: Please see Section 5.9.4.5(7) for discussion of uncertainties. Estimated numbers were rounded to one significant digit only for the purpose of this table.

Table L.2 Contributions to risk of early fatality with supportive medical treatment from spatial intervals within 50 miles (80 km) of Limerick site with Evac-Reloc* and Late Reloc* offsite emergency response modes

	Risk per reactor-year		
Spatial interval from (mi) - to (mi)†	From causes other than severe earthquakes (Evac-Reloc) (persons)	From servere earthquakes (Late Reloc) (persons)	Total (persons)
0.0 - 0.5**	2(-5)***	4(-5)	6(-5)
0.5 - 1.0	1(-5)	6(-5)	8(-5)
1.0 - 1.5****	4(-5)	3(-4)	3(-4)
1.5 - 2.0	4(-5)	3(-4)	4(-4)
2.0 - 2.5	4(-5)	4(-4)	4(-4)
2.5 - 3.0	2(-5)	3(-4)	4(-4)
3.0 - 3.5	3(-5)	6(-4)	6(-4)
3.5 - 4.0	2(-5)	5(-4)	6(-4)
4.0 - 4.5	6(-6)	3(-4)	3(-4)
4.5 - 5.0	2(-6)	3(-4)	3(-4)
5.0 - 6.0	9(-7)	3(-4)	3(-4)
6.0 - 7.0	4(-7)	2(-4)	2(-4)
7.0 - 8.5	1(-6)	3(-4)	3(-4)
8.5 - 10.0	6(-7)	2(-4)	2(-4)
10.0 - 12.5	2(-6)	3(-4)	3(-4)
12.5 - 15.0	2(-8)	2(-6)	2(-6)
15.0 - 17.5	3(-8)	5(-8)	8(-8)
17.5 - 20.0	4(-8)	0	4(-8)
20.0 - 25.0	0	0	0
25.0 - 30.0	0	7(-7)	7(-7)
30.0 - 35.0	0	0	0
35.0 - 40.0	0	0	0
40.0 - 45.0	0	0	0
45.0 - 50.0	0	0	0
Total	2(-4)	5(-3)	5(-3)

†To change miles to km, multiply the values shown by 1.609.
*See Section 5.9.4.5(2).
**This circular zone includes the Site Exclusion Area.
***2(-5) = 2×10^{-5} = .00002
****93% of the area of this annulus is included within an annulus 1-mile wide outside of the site exclusion area boundary.

NOTE: Please see Section 5.9.4.5(7) for discussion of uncertainties. Estimated numbers were rounded to one significant digit only for the purpose of this table.

Table L.3 Contributions to risk of early fatality with minimal medical treatment from spatial intervals within 50 miles (80 km) of Limerick site with Evac-Reloc* and Late Reloc* offsite emergency response modes

	Risk per reactor-year		
Spatial interval from (mi) - to (mi)†	From causes other than severe earthquakes (Evac-Reloc) (persons)	From servere earthquakes (Late Reloc) (persons)	Total (persons)
0.0 - 0.5**	5(-5)***	4(-5)	1(-4)
0.5 - 1.0	4(-5)	7(-5)	1(-4)
1.0 - 1.5****	8(-5)	3(-4)	4(-4)
1.5 - 2.0	6(-5)	4(-4)	5(-4)
2.0 - 2.5	7(-5)	5(-4)	6(-4)
2.5 - 3.0	5(-5)	4(-4)	5(-4)
3.0 - 3.5	6(-5)	8(-4)	8(-4)
3.5 - 4.0	5(-5)	7(-4)	8(-4)
4.0 - 4.5	2(-5)	4(-4)	4(-4)
4.5 - 5.0	2(-5)	4(-4)	4(-4)
5.0 - 6.0	1(-5)	4(-4)	5(-4)
6.0 - 7.0	3(-6)	4(-4)	4(-4)
7.0 - 8.5	3(-6)	5(-4)	5(-4)
8.5 - 10.0	7(-7)	5(-4)	5(-4)
10.0 - 12.5	9(-5)	1(-3)	1(-3)
12.5 - 15.0	9(-6)	1(-4)	1(-4)
15.0 - 17.5	1(-5)	5(-5)	7(-5)
17.5 - 20.0	1(-5)	2(-5)	3(-5)
20.0 - 25.0	1(-5)	1(-5)	3(-5)
25.0 - 30.0	2(-5)	2(-4)	2(-4)
30.0 - 35.0	1(-5)	9(-6)	2(-5)
35.0 - 40.0	7(-8)	1(-6)	1(-6)
40.0 - 45.0	3(-8)	8(-7)	9(-7)
45.0 - 50.0	3(-6)	3(-7)	3(-6)
Total	7(-4)	8(-3)	8(-3)

†To change miles to km, multiply the values shown by 1.609.
*See Section 5.9.4.5(2).
**This circular zone includes the Site Exclusion Area.
***5(-5) = 5 x 10^{-5} = .00005
****93% of the area of this annulus is included within an annulus 1-mile wide outside of the site exclusion area boundary.

NOTE: Please see Section 5.9.4.5(7) for discussion of uncertainties. Estimated numbers were rounded to one significant digit only for the purpose of this table.

Table L.4 Contributions to risk of latent cancer (including thyroid) fatality from spatial intervals within 50 miles (80 km) of Limerick site with Evac-Reloc* and Late Reloc* offsite emergency response modes

	Risk per reactor-year		
Spatial interval from (mi) - to (mi)†	From causes other than severe earthquakes (Evac-Reloc) (persons)	From severe earthquakes (Late Reloc) (persons)	Total (persons)
0.0 - 0.5**	3(-5)***	1(-6)	3(-5)
0.5 - 1.0	5(-5)	3(-6)	5(-5)
1.0 - 1.5****	2(-4)	2(-5)	2(-4)
1.5 - 2.0	2(-4)	3(-5)	2(-4)
2.0 - 2.5	2(-4)	4(-5)	3(-4)
2.5 - 3.0	2(-4)	4(-5)	2(-4)
3.0 - 3.5	3(-4)	9(-5)	4(-4)
3.5 - 4.0	3(-4)	9(-5)	4(-4)
4.0 - 4.5	1(-4)	5(-5)	2(-4)
4.5 - 5.0	1(-4)	5(-5)	2(-4)
5.0 - 6.0	2(-4)	8(-5)	2(-4)
6.0 - 7.0	2(-4)	8(-5)	2(-4)
7.0 - 8.5	2(-4)	1(-4)	4(-4)
8.5 - 10.0	2(-4)	1(-4)	4(-4)
10.0 - 12.5	3(-3)	8(-4)	4(-3)
12.5 - 15.0	1(-3)	2(-4)	1(-3)
15.0 - 17.5	2(-3)	4(-4)	3(-3)
17.5 - 20.0	2(-3)	4(-4)	2(-3)
20.0 - 25.0	7(-3)	1(-3)	8(-3)
25.0 - 30.0	1(-2)	2(-3)	2(-2)
30.0 - 35.0	6(-3)	1(-3)	7(-3)
35.0 - 40.0	5(-3)	8(-4)	6(-3)
40.0 - 45.0	2(-3)	3(-4)	2(-3)
45.0 - 50.0	2(-3)	3(-4)	2(-3)
Total	5(-2)	9(-3)	5(-2)

†To change miles to km, multiply the values shown by 1.609.
*See Section 5.9.4.5(2).
**This circular zone includes the Site Exclusion Area.
***3(-5) = 3×10^{-5} = .00003
****93% of the area of this annulus is included within an annulus 1-mile wide outside of the site exclusion area boundary.

NOTE: Please see Section 5.9.4.5(7) for discussion of uncertainties. Estimated numbers were rounded to one significant digit only for the purpose of this table.

APPENDIX M

AN ALTERNATIVE EVALUATION OF THE RELEASE CATEGORIES INITIATED BY CAUSES OTHER THAN SEVERE EARTHQUAKES

APPENDIX M

AN ALTERNATIVE EVALUATION OF THE RELEASE CATEGORIES INITIATED BY CAUSES OTHER THAN SEVERE EARTHQUAKES

The results presented in Sections 5.9.4.5(3), 5.9.4.5(4), and 5.9.4.5(6) and in Appendix L include contributions from the release categories initiated by severe earthquakes, and from the release categories initiated by internal causes, fires, and low to moderately severe earthquakes. The release categories not initiated by severe earthquakes were analyzed with the assumption of Evac-Reloc offsite emergency response mode (see Section 5.9.4.5(2) and Table 5.11f). To provide a reasonable bound to the role of evacuation in risk estimates from the latter release categories, as well as to display sensitivity of risks from these release categories with respect to pertubations in evacuation, an analysis of these release categories was made assuming the Early Reloc mode of offsite emergency response described in Section 5.9.4.5(2). The results of this analysis are provided in this appendix. Only the probability-weighted societal consequences (i.e., the societal risks) resulting from this alternative evaluation are presented below.

Tables M.1a and b are similar to Tables L.1a and b, respectively, in Appendix L. The numbers in the second columns of Tables M.1a and b are the estimates of risks of various kinds from the release categories initiated by causes other than severe earthquakes evaluated with the Early Reloc mode of offsite emergency response. The numbers in the third columns are reproduced from the third columns of Tables L.1a and b and are the estimates of risks ascribed to the severe earthquake-induced release categories as before. The numbers in the fourth columns represent alternative estimates of overall risks (for comparison with those shown in Table 5.11h) from release categories initiated by all causes, and are the sums of the numbers in the preceding columns for each risk type.

Number in parentheses in Tables M.1a and b below the entry for each type of risk (health effects and population exposure only) is the ratio of the risk estimate in these tables and the corresponding risk estimate in Tables L.1a and b. This ratio is indicative of the sensitivity of each type of risk to the choice between the Evac-Reloc and Early Reloc modes of offsite emergency response for the release categories initiated by causes other than severe earthquakes.

From inspection of the ratios (see above), it is apparent that the risk of early fatality (with supportive or minimal medical treatment) is most sensitive to the choice of emergency response mode. The risk of early fatality is about 3 to 4 times as large for the Early Reloc mode as that for the Evac-Reloc mode for release categories not initiated by severe earthquakes. However, because the risk of early fatality is dominated by the release categories initiated by severe earthquakes, the overall risk of early fatality with supportive or minimal medical treatment is only about 20% higher for the choice of the Early Reloc over the Evac-Reloc mode. The other types of risks in

Tables M.1a and b are less sensitive to the choice between the Early Reloc and Evac-Reloc modes.

Tables M.2, M.3, and M.4, respectively, display the contributions to the risks of early fatality with supportive medical treatment and with minimal medical treatment, and latent cancer (including thyroid) fatality from the spatial intervals within 50 miles (80 km) of the plant.

Table M.1a Societal risks within 50 miles (80-km) of Limerick site with Early Reloc* and Late Reloc* offsite emergency response modes

Consequence type	Risk per reactor-year		
	From causes other than severe earthquakes (Early Reloc)	From severe earthquakes (Late Reloc)	Total
1. Early fatalities with supportive medical treatment (persons)	1(-3)** (4)	5(-3)	6(-3) (1)
2. Early fatalities with minimal medical treatment (persons)	2(-3) (3)	8(-3)	1(-2) (1)
3. Early injuries (persons)	1(-2) (1)	1(-2)	2(-2) (1)
4. Latent cancer fatalities, excluding thyroid (persons)	4(-2) (1)	7(-3)	4(-2) (1)
5. Latent thyroid cancer fatalities (persons)	1(-2) (1)	2(-3)	1(-2) (1)
6. Total person-rems	6(2) (1)	9(1)	7(2) (1)
7. Cost of offsite mitigation measures (1980 dollars)	4(4)	5(3)	4(4)
8. Land area for long-term interdiction (square meters)	1(3)	1(2)	1(3)

*See Section 5.9.4.5(2).
**1(-3) = 1 x 10^{-3} = .001

NOTE: Please see Section 5.9.4.5(7) for discussion of uncertainties. Estimated numbers were rounded to one significant digit only for the purpose of this table.

Table M.1b Societal risks within the entire region of Limerick site with Early Reloc* and Late Reloc* offsite emergency response modes

Consequence type	Risk per reactor-year		
	From causes other than severe earthquakes (Early Reloc)	From severe earthquakes (Late Reloc)	Total
1. Early fatalities with supportive medical treatment (persons)	1(-3)** (4)	5(-3)	6(-3) (1)
2. Early fatalities with minimal medical treatment (persons)	2(-3) (3)	8(-3)	1(-2) (1)
3. Early injuries (persons)	1(-2) (1)	1(-2)	2(-2) (1)
4. Latent cancer fatalities, excluding thyroid (persons)	6(-2) (1)	1(-2)	7(-2) (1)
5. Latent thyroid cancer fatalities (persons)	1(-2) (1)	2(-3)	2(-2) (1)
6. Total person-rems	1(3) (1)	1(2)	1(3) (1)
7. Cost of offsite mitigation measures (1980 dollars)	5(4)	6(3)	5(4)
8. Land area for long-term interdiction (square meters)	1(3)	2(2)	1(3)

*See Section 5.9.4.5(2).
**1(-3) = 1 x 10^{-3} = .001

NOTE: Please see Section 5.9.4.5(7) for discussion of uncertainties. Estimated numbers were rounded to one significant digit only for the purpose of this table.

Table M.2 Contributions to risk of early fatality with supportive medical treatment from spatial intervals within 50 miles (80 km) of the Limerick site with Early Reloc* and Late Reloc* offsite emergency response modes

Spatial interval from (mi) - to (mi)†	Risk per reactor-year: From causes other than severe earthquakes (Early Reloc) (persons)	From severe earthquakes (Late Reloc) (persons)	Total (persons)
0.0 - 0.5**	6(-5)***	4(-5)	1(-4)
0.5 - 1.0	6(-5)	6(-5)	1(-4)
1.0 - 1.5****	2(-4)	3(-4)	5(-4)
1.5 - 2.0	2(-4)	3(-4)	5(-4)
2.0 - 2.5	1(-4)	4(-4)	5(-4)
2.5 - 3.0	1(-4)	3(-4)	4(-4)
3.0 - 3.5	1(-4)	6(-4)	7(-4)
3.5 - 4.0	9(-5)	5(-4)	6(-4)
4.0 - 4.5	3(-5)	3(-4)	3(-4)
4.5 - 5.0	3(-5)	3(-4)	3(-4)
5.0 - 6.0	2(-5)	3(-4)	3(-4)
6.0 - 7.0	6(-6)	2(-4)	3(-4)
7.0 - 8.5	2(-6)	3(-4)	3(-4)
8.5 - 10.0	6(-7)	2(-4)	2(-4)
10.0 - 12.5	2(-6)	3(-4)	3(-4)
12.5 - 15.0	2(-8)	2(-6)	2(-6)
15.0 - 17.5	3(-8)	5(-8)	8(-8)
17.5 - 20.0	4(-8)	0	4(-8)
20.0 - 25.0	0	0	0
25.0 - 30.0	0	7(-7)	7(-7)
30.0 - 35.0	0	0	0
35.0 - 40.0	0	0	0
40.0 - 45.0	0	0	0
45.0 - 50.0	0	0	0
Total	1(-3)	5(-3)	6(-3)

†To change miles to km, multiply the values shown by 1.609.
*See Section 5.9.4.5(2).
**This circular zone includes the Site Exclusion Area.
***6(-5) = 6×10^{-5} = .00006
****93% of the area of this annulus is included within an annulus 1-mile wide outside of the site exclusion area boundary.

NOTE: Please see Section 5.9.4.5(7) for discussion of uncertainties. Estimated numbers were rounded to one significant digit only for the purpose of this table.

Table M.3 Contributions to risk of early fatality with minimal medical treatment from spatial intervals within 50 miles (80 km) of the Limerick site with Early Reloc* and Late Reloc* offsite emergency response modes

	Risk per reactor-year		
Spatial interval from (mi) - to (mi)†	From causes other than severe earthquakes (Early Reloc) (persons)	From severe earthquakes (Late Reloc) (persons)	Total (persons)
0.0 - 0.5**	8(-5)***	4(-5)	1(-4)
0.5 - 1.0	1(-4)	7(-5)	2(-4)
1.0 - 1.5****	3(-4)	3(-4)	7(-4)
1.5 - 2.0	3(-4)	4(-4)	7(-4)
2.0 - 2.5	3(-4)	5(-4)	8(-4)
2.5 - 3.0	2(-4)	4(-4)	6(-4)
3.0 - 3.5	3(-4)	8(-4)	1(-3)
3.5 - 4.0	3(-4)	7(-4)	1(-3)
4.0 - 4.5	1(-4)	4(-4)	5(-4)
4.5 - 5.0	8(-5)	4(-4)	4(-4)
5.0 - 6.0	6(-5)	4(-4)	5(-4)
6.0 - 7.0	3(-5)	4(-4)	4(-4)
7.0 - 8.5	2(-5)	5(-4)	6(-4)
8.5 - 10.0	2(-5)	5(-4)	5(-4)
10.0 - 12.5	9(-5)	1(-3)	1(-3)
12.5 - 15.0	9(-6)	1(-4)	1(-4)
15.0 - 17.5	1(-5)	5(-5)	7(-5)
17.5 - 20.0	1(-5)	2(-5)	3(-5)
20.0 - 25.0	1(-5)	1(-5)	3(-5)
25.0 - 30.0	2(-5)	2(-4)	2(-4)
30.0 - 35.0	1(-5)	9(-6)	2(-5)
35.0 - 40.0	7(-8)	1(-6)	1(-6)
40.0 - 45.0	3(-8)	8(-7)	9(-7)
45.0 - 50.0	3(-6)	3(-7)	3(-6)
Total	2(-3)	8(-3)	1(-2)

†To change miles to km, multiply the values shown by 1.609.
*See Section 5.9.4.5(2).
**This circular zone includes the Site Exclusion Area.
***8(-5) = 8 x 10^{-5} = .00008
****93% of the area of this annulus is included within an annulus 1-mile wide outside of the site exclusion area boundary.

NOTE: Please see Section 5.9.4.5(7) for discussion of uncertainties. Estimated numbers were rounded to one significant digit only for the purpose of this table.

Table M.4 Contributions to risk of latent cancer (including thyroid) fatality from spatial intervals within 50 miles (80 km) of the Limerick site with Early Reloc* and Late Reloc* offsite emergency response modes

Spatial interval from (mi) - to (mi)†	Risk per reactor-year: From causes other than severe earthquakes (Early Reloc) (persons)	From severe earthquakes (Late Reloc) (persons)	Total (persons)
0.0 - 0.5**	4(-5)***	1(-6)	4(-5)
0.5 - 1.0	7(-5)	3(-6)	7(-5)
1.0 - 1.5****	3(-4)	2(-5)	3(-4)
1.5 - 2.0	3(-4)	3(-5)	3(-4)
2.0 - 2.5	4(-4)	4(-5)	4(-4)
2.5 - 3.0	4(-4)	4(-5)	4(-4)
3.0 - 3.5	6(-4)	9(-5)	7(-4)
3.5 - 4.0	6(-4)	9(-5)	7(-4)
4.0 - 4.5	3(-4)	5(-5)	3(-4)
4.5 - 5.0	3(-4)	5(-5)	3(-4)
5.0 - 6.0	4(-4)	8(-5)	4(-4)
6.0 - 7.0	3(-4)	8(-5)	4(-4)
7.0 - 8.5	5(-4)	1(-4)	6(-4)
8.5 - 10.0	5(-4)	1(-4)	6(-4)
10.0 - 12.5	3(-3)	8(-4)	4(-3)
12.5 - 15.0	1(-3)	2(-4)	1(-3)
15.0 - 17.5	2(-3)	4(-4)	3(-3)
17.5 - 20.0	2(-3)	4(-4)	2(-3)
20.0 - 25.0	7(-3)	1(-3)	8(-3)
25.0 - 30.0	1(-2)	2(-3)	2(-2)
30.0 - 35.0	6(-3)	1(-3)	7(-3)
35.0 - 40.0	5(-3)	8(-4)	6(-3)
40.0 - 45.0	2(-3)	3(-4)	2(-3)
45.0 - 50.0	2(-3)	3(-4)	2(-3)
Total	5(-2)	9(-3)	6(-2)

†To change miles to km, multiply the values shown by 1.609.
*See Section 5.9.4.5(2).
**This circular zone includes the Site Exclusion Area.
***4(-5) = 4 x 10^{-5} = .00004
****93% of the area of this annulus is included within an annulus 1-mile wide outside of the site exclusion area boundary.

NOTE: Please see Section 5.9.4.5(7) for discussion of uncertainties. Estimated numbers were rounded to one significant digit only for the purpose of this table.

APPENDIX N

CRITIQUE OF APPLICANT'S CONSEQUENCE ANALYSIS IN LIMERICK GENERATING STATION ENVIRONMENTAL REPORT-OPERATING LICENSE (ER-OL)

APPENDIX N

CRITIQUE OF APPLICANT'S CONSEQUENCE ANALYSIS IN LIMERICK GENERATING STATION ENVIRONMENTAL REPORT-OPERATING LICENSE (ER-OL)

In the ER-OL, a total of 11 source terms (or release categories) were used. Some of these release categories were the result of binning (or grouping) of several individual source terms. In some of the bins, the member source terms had very dissimilar release characteristics and release fractions, and the source terms selected to represent the bins were considered by the staff to be unrepresentative of the bins. For this reason, the staff did not use the ER-OL binning of the source terms and chose to use a greater number and more consistent set of release categories in its consequence analysis. However, the 11 different sets of release fractions (source terms) used in the ER-OL and the 27 release categories used in the staff analysis are intended to encompass an equivalent number of combinations of the plant damage states and containment failure modes.

The point estimates of radionuclide release fractions for the 11 source terms in the ER-OL are generally lower and warning times for evacuation associated with some of these source terms are longer than those for the release categories used in the staff analysis. However, exact comparison of source term specifications between those in ER-OL and in the staff analysis is difficult because of the different numbers of source terms used in the two analyses.

The point estimates of probabilities of the source terms in the ER-OL add up to 6×10^{-6} per reactor-year for seismic causes and 4×10^{-5} per reactor-year for non-seismic causes. The staff analysis uses the same total value for the point estimates of the probabilities of the seismically induced release categories; however, the staff's total of the point estimates of the probabilities of non-seismically induced release categories is 9×10^{-5} per reactor-year.

The consequence analysis in the ER-OL used the CRAC2 computer code, which is a modified version of the CRAC code used in the Reactor Safety Study (WASH-1400 NUREG-75/014). Both CRAC2 and the staff version of CRAC (1980) incorporate the same evacuation model which is revised from that used in WASH-1400. The revised evacuation model is capable of incorporating people's delay time before evacuation in addition to their speed during evacuation. Both the codes are also capable of modeling a variety of offsite emergency response options--such as shelter and relocation--in addition to evacuation separately or in combination. CRAC2 incorporates a modified scheme for sampling the weather data in addition to the usual sampling schemes of CRAC. However, using the modified weather sampling scheme of CRAC2 and the stratified sampling scheme of CRAC, both the codes produced almost identical results, within likely uncertainty bands, in international benchmark exercises for comparison of codes used in consequence analysis. Therefore, the use of CRAC2 in the ER-OL is acceptable to the staff. However, the staff chose to use CRAC for its independent consequence analysis for two reasons:

(1) Although CRAC and CRAC2 produced almost equal results, within likely uncertainty bands, for benchmark problems, there are some differences in results produced by the two codes for other problems which have yet to be properly explained. A detailed comparison between CRAC and CRAC 2 has been sponsored by the staff at Oak Ridge National Laboratory. After the differences between the two codes are understood, the staff may use CRAC2, with or without any additional modifications, in future applications.

(2) The other reason for using CRAC in the staff analysis is that the staff has used the 1980 version of CRAC in severe accident consequence analyses in the environmental statements issued after July 1, 1980, pursuant to the Commission Statement of Interim Policy, June 13, 1980 (45 FR 40101-40104). The staff has provided a comparison of risk estimates for Limerick with those made using CRAC in environmental statements for other plants and the use of CRAC2 could prove inconsistent.

Five years' worth of meteorological data (from 1972 to 1976) was used in the ER-OL consequence analysis after some modifications were made to CRAC2, which normally uses only 1 year of meteorological data. In response to the staff question as to the degree of improvement achieved by using 5 years of data, the applicant provided a comparison of CRAC2 runs for sample problems using each of the five 1-year data periods separately with those using data for the entire 5-year period. The comparison did not show much difference between these runs. Further, in response to the staff question regarding the adequacy of the number of weather sequences sampled from 5 years of data, the applicant presented a comparison of CRAC2 runs for sample problems with increased weather sequence samples. No appreciable difference as a result of the increased sampling was noticed. Therefore, the use of 5 years' worth of meteorological data and the sampling scheme in the ER-OL are acceptable to the staff.

The ER-OL analysis used a core inventory of radionuclides (excluding activation products) calculated for a BWR at a power level of 3293 MWt. However, the staff analysis used 105% of this power level (3458 MWt), and calculated the core inventory based upon WASH-1400 estimates of fission and activation product distributions. The use of a lower power level would result in lower offsite consequences.

The ER-OL analysis used an estimated population distribution for the year 2000 up to 500 miles (800 km) from the plant, and economic data related to land use on county-wide basis up to 50 miles (80 km) and on a state-wide basis outside 50 miles (80 km). These are acceptable to the staff, although staff used its own estimates of inputs to the CRAC code. The other economic data in the ER-OL are not site specific, but they are site-specific in the staff analysis.

For releases not caused by severe earthquakes, the ER-OL analysis used a generic set of parameters for evacuation within the 10-mile (16-km) Emergency Planning Zone (EPZ): 1-, 3-, and 5-hour delay times with probabilities of 0.3, 0.4, and 0.3, respectively, and 10 mph (16 km per hour) for effective evacuation speed. Because this is not site specific, it is unacceptable to the staff. A study prepared by the NUS Corporation for the applicant in 1980 provides a basis for the estimate of effective evacuation speed of about 2.5 mph (4 km per hour), considering the road network and the expected traffic loading for evacuation from the 10-mile (16-km) EPZ during emergency. The estimate of the site-specific delay time of about 5 hours made in the NUS study was rejected by the applicant because the study did not take into account the early warning system that would be required for notification of emergency before the plant would be licensed for operation. The staff recognizes the applicant's position. However, in lieu of any available estimate of delay time for the site, the staff assumed a delay time of 2 hours, which is consistent with similar estimates for other high population density sites. The ER-OL assumed a maximum distance of 20 miles (32 km) traveled by the evacuees; however staff used 15 miles (24 km) for this distance, as it has for other plants. The staff assumptions of 2 hours for delay time, 2.5 mph (4 km per hour) of evacuation speed, and a travel distance of 15 miles (24 km) are applied to the situations of releases as a result of plant-internal causes, fires, and low to moderately severe earthquakes (see Section 5.9.4.5(2) for an alterative to the assumption of evacuation from the 10-mile (16-km) EPZ). For these situations, the ER-OL also assumes relocation of people from the 10- to 25-mile (16- to 40-km) region 12 hours after passage of radioactive plume. Although a similar assumption has been made by the staff in the consequence analyses in the environmental statements for several other plants, the staff judgment is that this assumption for a site with high population density would not be appropriate because the large number of people that would be involved in the 10- to 25-mile (16- to 40-km) region would make this scenario unrepresentative. Instead, the staff analysis assumes that outside of the 10-mile (16-km) EPZ, only people from the highly contaminated areas (see Section 5.9.4.5(2)) would be relocated 12 hours after plume passage. Shielding factors used in the ER-OL are: (1) the same as in the staff analysis during evacuation, (2) higher than the staff's during delay before evacuation, and (3) lower than the staff's during waiting before relocation. The values used by the staff are the same as those used in WASH-1400. The impact of differences in shielding factors used in the ER-OL from those in WASH-1400 is difficult to assess, although it is not likely to be substantial.

For releases caused by severe earthquakes, the ER-OL assumes evacuation from the 10-mile (16-km) EPZ after a 3-hour delay with an effective speed of 0.5 meter/sec, and relocation from 10- to 25-mile (16- to 40-km) region 24 hours after plume passage. However, the severity of earthquakes assumed is Modified Mercalli intensity scale of IX or higher, and it is the judgment of the staff that earthquakes of such severity would cause very extensive damage in the site region that would seriously hamper the evacuation. Therefore, the staff assumed no evacuation for these situations but, instead, assumed relocation of people from highly contaminated areas 24 hours after plume passage. Shielding factors used by the staff are also more pessimistic. The ER-OL analysis assumed an effective peak ground acceleration of 0.61g or more to be associated with Modified Mercalli intensity scales of IX of higher. However, the staff used 0.4g as the dividing line, although it recognizes that there is lack of actual recordings of effective peak ground accelerations associated with the intensity scales. It is the staff's judgment that although a range of effective peak ground acceleration of 0.35g to 0.5g would be more appropriate, the results of consequence analysis are not sensitive to the choice of values within a range of 0.35g to 0.5g. Therefore, the staff used only the single value of 0.4g. The ER-OL assumptions regarding the offsite emergency response during severe earthquake conditions as well as the assumption of 0.61 g as the dividing line for classification of less severe and very severe earthquakes result in lower estimates of risks from seismically induced source terms.

The ER-OL point estimates of risk from the 11 source terms and the staff's point estimates of risks from 27 release categories are as follows:

Type of risk	Risk per reactor-year	
	ER-OL*	Staff
1. Early fatalities with supportive medical treatment (persons)	3(-4)**	5(-3)
2. Latent cancer fatalities excluding thyroid (persons)		
50-mile (80-km) region	2(-2)	4(-2)
Entire region	3(-2)	7(-2)
3. Latent thyroid cancer fatalities (persons)		
50-mile (80-km) region	5(-3)	1(-2)
Entire region	6(-3)	1(-2)
4. Whole body person-rems		
50-mile (80-km) region	300	700
Entire region	500	1000
5. Cost of offsite mitigation measures (1980 dollars)	20,000	50,000

*On March 13, 1984, the applicant informed the staff that the ER-OL consequence calculations are being revised and that the revised calculations will not result in significant changes in the results currently presented in the ER-OL. Based upon the applicant's explanation of the source of the error, the staff judges that the impact of these revisions will be relatively small.

**3(-4) x 10^{-4} = .0003. Estimated numbers were rounded to one significant digit only for the purpose of this table.

In the ER-OL, an uncertainty analysis on risks is provided with respect to four major parameters

(1) probability of each source term

(2) magnitude and other release characteristics of some of the dominant source terms

(3) evacuation and sheltering parameters

(4) dose-response relationships for early fatality with three types of medical treatment

The first of these parameters was treated by system analysis and standard methods of combining uncertainties. The other three were treated by a sensitivity study using the CRAC2 code to provide a large number of conditional CCDFs for the 11 different sets of release fractions (source terms). These CCDFs were used to define the upper and lower conditional CCDFs for the source terms. The upper and lower CCDFs were combined probabilistically with the uncertainity distribution on source term probabilities in order to generate the uncertainty bands on the overall CCDFs.

The variations used in source term parametrization were mostly subjective. For offsite emergency response the evacuation speed was varied from 2.5 to 10 mph (4 to 16 km an hour), while the delay time before evacuation ranged from 1 to 5 hours. For severe earthquake conditions, no variation in the parameters of offsite emergency response was made. For the 10- to 25-mile (16- to 40-km) region, sheltering in basements for 24 hours followed by rapid relocation was used; the 25-mile (40-km) distance was also extended to 50 miles (80 km). Considering that the state of the art of uncertainty assessment in consequence analysis is not well developed, this method of uncertainty analysis in the ER-OL is acceptable to the staff. However, the lack of any variation in the pessimistic direction in offsite emergency response parameters for the severe earthquake conditions and too many variations in the optimistic direction for nonsevere earthquake conditions, and the lack of variation in the source terms to encompass some of the high values of the release fractions as used in the staff analysis, lead the staff to disagree with the upper estimates of the overall CCDFs in the ER-OL.

By letter, dated March 13, 1984, PECo states that errors had been discovered in the ER-OL consequence analysis. PECo has further stated that these errors, when corrected, will not significantly alter the ER-OL conclusions.

The staff also performed a limited sensitivity analysis. With respect to variation of probability of earthquake-induced release categories, the staff concluded that the staff's point estimates of risks could be exceeded by factors of up to 6, but could also be lower by factors up to 3. With respect to parameters of offsite emergency response the overall risks could be increased by up to 20%. With respect to medical treatment, the risk of early fatality could have a spread within factors of 2 to 3. The staff has not performed a sensitivity study with respect to probabilities of release categories initiated by causes other than severe earthquakes, source terms, and other elements that contribute to uncertainties. Based upon the insight gained from review of similar PRAs for Indian Point and Zion, it is the judgment of the staff that the staff's Limerick risk estimates could be too low by a factor of about 40 or too high by a factor of about 400.

APPENDIX O

DELAWARE RIVER BASIN COMMISSION COMMENTS ON WATER RESOURCES

DELAWARE RIVER BASIN COMMISSION
P.O. BOX 7360
WEST TRENTON, NEW JERSEY 08628

(609) 883-9500

GERALD M. HANSLER
EXECUTIVE DIRECTOR

HEADQUARTERS LOCATION
25 STATE POLICE DRIVE
WEST TRENTON, N.J.

February 27, 1984

Dear Sir:

We recently sent you our January 1984 staff responses to comments from the U. S. Department of the Interior on the Draft Environmental Statement relating to the operating license for the Limerick Generating Station, Montgomery County, Pennsylvania.

It is our understanding that you intend to append the DRBC staff comments to the Final Environmental Statement. For this purpose, we are sending you the enclosed original typescript of our staff comments as corrected and revised slightly and dated February 1984. Please use this corrected version and discard the superseded January 1984 version.

Please let us know if we can be of further help.

Sincerely,

Gerald M. Hansler

U. S. Nuclear Regulatory Commission
Attention: Director of Division of Licensing
Washington, D. C. 2055

Enc.

cc: Commissioner George J. Kanuck, Jr. (w/enc.)

DRBC Staff Responses to Comments from
U.S. Department of the Interior on Draft Environmental
Impact Statement on the Limerick Generating Station
Montgomery County, Pennsylvania

February 1984

Introduction

In June 1983, the U.S. Nuclear Regulatory Commission (NRC) issued a Draft Environmental Statement (DES) related to the operation of the Limerick Electric Generating Station, Units 1 and 2, currently under construction on the Schuylkill River in Montgomery County, Pennsylvania. By letter of August 26, 1983, the U.S. Department of the Interior (DOI) transmitted comments on the DES to the NRC, and a copy of the DOI letter was received by the Delaware River Basin Commission (DRBC), the agency that manages the water resources of the Delaware River Basin pursuant to the Delaware River Basin Compact (Public Law 87-328, Approved September 27, 1961, 75 Statutes at Large 688). The DRBC had earlier approved the use of water for the Limerick Station from the Schuylkill River, Perkiomen Creek, and the Delaware River, all with certain restrictions and limits (DRBC Docket Number D-69-210 CP--Final).

Many of the DOI comments relate to the use of water for the Limerick project, as approved by the DRBC, and include requests for clarification. Such clarification should logically come from the DRBC. For this reason, the DRBC staff has prepared responses to those DOI comments that are related to the use of water from the Schuylkill River, Perkiomen Creek, and the Delaware River, as well as those comments related to water quality in these streams, and also in the East Branch Perkiomen Creek, which is to convey Delaware River water to Perkiomen Creek.

For convenient reference, the DRBC staff responses are presented under the headings given in the DOI letter.

Surface water hydrology

The DOI letter objected to the statement in section 4.3.1.1.3 that upstream reservoirs are capable of maintaining a flow of 3,000 cfs in the

Delaware River at Trenton during a moderate drought. The DOI cited records showing Trenton flows less than 2,500 cfs during the recent moderate drought of 1980-81. We believe that the DOI is confusing flow-maintenance capability of existing reservoirs with actual reservoir operations during that drought, in which the DRBC, not knowing how long the drought would last, deemed it prudent to conserve water in storage by reducing the minimum flow objective at Trenton from the normal rate of 3,000 cfs to 2,500 cfs. With hindsight, we know now that we could have easily maintained 3,000 cfs at Trenton during the dry period of 1980 and 1981. However, water supply managers do not have the ability to foresee the future, and they must frequently act on the basis of current facts and future risks. The fact that 3,000 cfs flows were not maintained at all times during the 1980-81 drought does not mean that the existing reservoirs system did not have that capability; it means only that the DRBC chose to conserve water against the possibility of an extended severe drought.

On June 29, 1983, the DRBC adopted reservoir operating rules that will automatically reduce the Trenton flow objective at Trenton whenever the combined storage in New York City's three Delaware Basin reservoirs drops to a predetermined "drought warning" or "drought" level, as set forth in Resolution 83-13 (appendix A). For the drought-warning condition, the Trenton flow objective will be 2,700 cfs. For drought conditions, the target flow will vary from 2,500 cfs to 2,900 cfs, depending on the season and salinity levels in the estuary, as measured by the seven-day average location of the 250-mg/l isochlor (the "salt front").

The DOI notes that during the period of record historical flows at Trenton have dropped below 2,500 cfs at least once in every calendar month of one year or another except March, April, and May with 90 percent of the existing upstream storage in operation. This 90 percent of the now existing reservoir capacity above Trenton represents the storage capacity in New York City's three upper-basin reservoirs (Pepacton, Cannonsville, and Neversink). These reservoirs are operated to meet a flow objective at Montague, N.J., in accordance with the U.S. Supreme Court decree of 1954 in New Jersey v. New York, 347 U.S 955 (1954), and are not operated to meet any flow objective at Trenton. However, in maintaining minimum flows at Montague, the New York City reservoirs do augment low river flows as measured at Trenton. Nevertheless, it is not surprising that releases to meet a Montague flow objective, without additional releases from other reservoirs, do not always meet the Trenton flow objective.

Beltzville Reservoir began regulating flows in February 1971, and at that time increased the flow capability at Trenton. Observed Trenton flows preceding that date should not be used to judge current (1983) flow capability at Trenton, unless these flows are adjusted to show the effects of current regulation. Based on computerized mathematical models of the existing basin hydrologic system, the DRBC staff has estimated that in a 1983 recurrence of the hydrology of 1965, the driest year of record, a minimum four-month (June-September) average flow of 2,470 cfs could be provided, assuming operation of the system in accordance with DRBC Resolution 83-13. Although this level of flow regulation at Trenton, together with flow regulation by Blue Marsh Reservoir in the Schuylkill River basin, will prevent violation of the recently adopted salinity standard for the estuary, it is projected that additional storage will be required by about 1987 to protect the salinity standard.

The DOI notes that daily flows at Trenton dropped below 2,500 cfs during several months in 1977, 1980, and 1981. The specific dates, along with the average daily flows and the mean monthly flows, are listed in table 1. These data are taken from the annual reports on water resources data for New Jersey, published by the U.S. Geological Survey (USGS), which operates the stream-gaging station at Trenton. These data show for each of four months in 1977 one day on which the flow averaged less than 2,500 cfs. The minimum monthly mean flow for these four months was 3,515 cfs (August 1977).

There were three days in December 1980 on which the daily flow was less than 2,500 cfs; the monthly mean flow for December was 3,784 cfs.

According to the published USGS records, there were only two months in 1981, not three--as stated by the DOI, during which a daily flow was less than 2,500 cfs. In January 1981, the flow at Trenton was below 2,500 cfs on 13 days; the mean flow for the month was 2,539 cfs. In February 1981, for which

Table 1.--Delaware River at Trenton, N. J.--
Daily Mean Flows less than 2,500 cfs, with
Monthly Means Flow for such Occurrences,
1977, 1980, and 1981

Date(s)	Mean flow, cfs	Date(s)	Mean flow, cfs
Jan. 31, 1977	2,250	Jan. 5, 1981	1,900
Jan. 1-31, 1977	3,755	Jan. 6, 1981	2,280
		Jan. 9, 1981	2,400
Feb. 1, 1977	2,200	Jan. 10, 1981	2,430
Feb. 1-28, 1977	7,511	Jan. 11, 1981	2,330
		Jan. 12, 1981	2,350
July 29, 1977	2,440	Jan. 13, 1981	2,210
July 1-31, 1977	3,723	Jan. 14, 1981	2,370
		Jan. 15, 1981	2,430
Aug. 30, 1977	2,490	Jan. 18, 1981	2,420
Aug. 1-30, 1977	3,515	Jan. 31, 1981	2,410
		Jan. 1-31, 1981	2,539
Dec. 22, 1980	2,420		
Dec. 23, 1980	2,370	Feb. 1, 1981	2,280
Dec. 27, 1980	2,390	Feb. 1-28, 1981	22,790
Dec. 1-31, 1980	3,784		
Jan. 3, 1981	2,400		
Jan. 4, 1981	2,150		

Source: U. S. Geological Survey

the Trenton flow averaged 22,790 cfs, there was only one day on which the daily mean flow was less than 2,500 cfs.

The infrequent low daily flows listed in table 1 do not represent severe problems. There were only 21 days in the five-year period from 1977 through 1981 with daily Trenton flows less than 2,500 cfs. There were seven months during this five-year period during which the flow dropped below 2,500 cfs for one or more days. Five of these months and 19 of the 21 days were either in January or February, the time of year when low river flows are not critical with respect to the needs for protection of stream uses. Only two of the low-flow days, one in July 1977 and one in August 1977, occurred in the critical summer period when stream values are sensitive to flow levels. With mean monthly flows of 3,723 cfs and 3,515 cfs, respectively, for these months, the isolated one-day flow deficiencies would not cause any problems in the river or estuary. For example, the single low-flow in July 1977 (2,440 cfs on July 29) would not cause a salinity change in the Delaware estuary; the salinity at any time is dependent on a long series of antecedent flows over several months. Thus, if the flow on July 29 had been increased to 3,000 cfs, it would not have resulted in a significant change in estuarine salinity.

<u>Cause of low flows.</u>—The DOI seems to imply that the observed occasional daily flows below 2,500 cfs in 1977, 1980, and 1981 resulted from inadequate storage capacity. However, this was not the case. The reason the Trenton flow was occasionally less than the objective is related to difficulties experienced by the Deputy Delaware River Master in scheduling reservoir releases to meet the minimum flow objective at Montague, N.J., where compliance with the Montague formula for minimum flow, as specified in the 1954 decree of the U.S. Supreme Court, is checked. Any flow deficits from this cause at Montague are reflected in the flows measured at Trenton about two days later. The Deputy River Master is an employee of the Department of Interior.

If these deficits had been significant, they could have been offset by releases from Beltzville Reservoir on the Lehigh River, where water was available in storage. However, whenever design releases (basic releases plus excess releases) directed by the River Master prove to be too low to meet the

Montague flow objective, extra releases are scheduled by the River Master over the next 10 days or more to maintain the average flow at or above the objective.

The DRBC is currently conferring with the River Master's office to improve the scheduling of releases from New York City's upper-basin reservoirs as necessary to decrease the already low frequency of flow deficits at Montague. In the meantime, it should be emphasized that although operational problems have led to infrequent flow deficits at both Montague and Trenton, these operational problems are subject to better control. Moreover, because of their infrequent occurrence, short duration, or season of occurrence, they have not resulted in any detectable problem related to instream water uses.

The DOI states that the DRBC "...now admits (emphasis added) that by the year 2000, they may not be able to maintain 2,300 cfs flow at Trenton because of increased consumptive losses in the Basin...", and that "...the DRBC recognizes that several more large reservoirs must be constructed in the basin to achieve the minimum flow objectives at Trenton." It is misleading to characterize these long-known facts, widely proclaimed by the DRBC for many years, either as recent or as an admission. Since 1962, the DRBC has called for additional reservoirs in the Basin to augment low flows of the Delaware River. More recent projections of demand have allowed delays in construction of additional storage capacity. However, as a result of recommendations in the final Level-B report and the "Good Faith" report, the DRBC has four additional storage projects planned for development by the year 2000.

What the DOI has failed to state regarding DRBC's management of the Delaware River is that even if minimum daily flows fall to the 2,400 to 2,500 cfs levels during a drought emergency, that minimum flow level is much greater than the 1,100 cfs drought-flow levels available before upstream impoundments gave us an increased flow-maintenance capability. And, this more than doubling of minimum reliable flows (2,500 cfs vs 1,100 cfs) helps all instream uses, including fish, wildlife, and recreation.

Relation of low flows to Limerick project.--The DOI comments regarding observed Trenton flows less than 2,500 cfs have little relevance to the decision to be guided by the environmental impact statement. The DRBC has specified that whenever the Trenton flow is less than 3,000 cfs, water can be diverted from the Delaware River for use at the Limerick generating station only if the diverted water is replaced from storage, that is, from Merrill Creek Reservoir or an alternate facility. Therefore, the Trenton flows below 3,000 cfs will not be reduced by the Limerick diversions.

Perkiomen Creek flows.--The DOI suggested clarification of the requirements for maintenance of flows in Perkiomen Creek and its East Branch. The pumping rate of 27 cfs applies to the withdrawal from the Delaware River. No rate is specified for withdrawals from Bradshaw Reservoir, but these withdrawals must be adequate, when combined with natural runoff in the East Branch, to give a flow of 27 cfs in the East Branch at the Bucks Road stream gage. The DRBC approval of the Bradshaw Reservoir water supply is subject to various conditions, including maintenance of a minimum flow of 27 cfs in the East Branch Perkiomen Creek throughout each low flow period when pumping from the Delaware River is required for the operation of the Limerick generating station. The rest of the year PECO must maintain a minimum flow of 10 cfs in the East Branch. There is no requirement for Bradshaw Reservoir releases to maintain low flows in the main stem of Perkiomen Creek. However, augmentation of low flows in the East Branch will incidentally augment the flows in the main stem. (See DRBC Docket No. D-79-52 CP--Bradshaw Reservoir, etc.)

The DRBC approval of the water supply for the Limerick generating station (Docket No. D-69-210 CP(Final)) specifies that Perkiomen Creek may be used as the source when flows as measured at the Graterford gage are in excess of 180 cfs with one generating unit in operation or in excess of 210 cfs with two units in operation.

Potential water loss.--The DOI suggested that the estimated 10-percent loss of water in transport from the Delaware River to the Limerick station may be conservative (low), considering evaporative losses in Bradshaw Reservoir and over 23 miles of Perkiomen Creek, leakage from transmission pipes, channel storage, and ground-water intrusion.

The greatest transit loss by evaporation will be from the surface of Bradshaw Reservoir, with a surface area of 18 acres. Based on a maximum evaporation rate of 0.25 inches per day, this loss will not exceed 0.122 mgd (0.2 cfs).

The evaporative transit losses in the East Branch Perkiomen Creek and in the short reach of Perkiomen Creek between the East Branch and the withdrawal intake will be a function of temperature and incremental water-surface area added to these stream reaches by the flow augmentations from Bradshaw Reservoir. Except in short reaches where the natural streambed is dry, flow augmentation will add very little surface area, and the stream temperature will not be increased significantly. Therefore, flow augmentation will cause very little incremental evaporation from the streams used for conveyance.

The DOI expressed concern that transit losses may be higher than estimated because of potential seepage through the streambed to nearby overpumped aquifers. The total stream loss to the aquifers is a function of the area of the wetted permeable streambed and the hydraulic gradient between the stream surface and the water table in the aquifer. The incremental wetted streambed and incremental hydraulic head will be very small for the stream conveyance system. Therefore, the increase in stream losses to aquifers attributable to flow augmentations will be correspondingly small.

The maximum withdrawal from Perkiomen Creek for supplemental cooling water (42 mgd) was determined by combining the maximum evaporative loss in the cooling system with the maximum miscellaneous and drift loss at the Limerick station, even though these losses are not expected to occur concurrently (see DES, section 4.3.1.2, page 4-24). The transit-loss allowance of 4.2 mgd (6.5 cfs) is 10 percent of the conservatively high estimate of 42 mgd for the Perkiomen Creek withdrawal. The Point Pleasant pumping station is sized to withdraw 46.2 mgd from the Delaware River for Limerick, including the liberally estimated increment of 4.2 mgd for transit losses. If, as expected, the actual evaporative losses, etc., at the Limerick station are less than 42 mgd, the difference between the Delaware River withdrawal and the actual station losses will be greater than 4.2 mgd, and this difference--available to offset transit losses--will be greater than 10 percent of the Perkiomen Creek withdrawal.

The DRBC staff believes the allowance for 10-percent transit losses is reasonable, and probably conservatively high.

Aquatic resources

The DOI stated that the area in the vicinity of the Point Pleasant intake is expected to be more heavily used for spawning by alosid fishes in the future.

Even though all existing spawning areas, including the Point Pleasant area, might be more heavily used for alosid spawning in the future, hundreds of miles of main stem and tributaries are already used as spawning grounds. The Point Pleasant intake will be a state-of-the-art design to minimize impingement and entrainment. Operation of the intake at Point Pleasant will be insignificant when considering the remaining vast spawning areas, and exploitation of female shad by commercial and sport fisheries. Moreover, the applicant (Neshaminy Water Resources Authority) is required to monitor the operation of the intake and, if necessary, provide mitigation measures (see condition "m", DRBC Docket D-65-76 CP(8)).

Water use and treatment

The DOI compared the maximum withdrawal from the Delaware River at Point Pleasant as noted on page 4-10 of the DES (71 cfs) with the maximum use of Delaware River/Perkiomen Creek water at the Limerick generating station as given in table 4.1, page 4-4 (57.4 cfs), and concluded that this means a transit loss of the difference (13.6 cfs). The Point Pleasant withdrawal figure on page 4-10, 71 cfs, is rounded to the nearest cfs. If the transit loss is to be calculated to the nearest tenth of a cfs, then the Point Pleasant withdrawal should be taken as 71.5 cfs, and the difference between 71.5 cfs and 57.4 cfs would be 14.1 cfs. However, it does not follow that the transit loss should be calculated as the difference between the two maximums, which may not occur concurrently. It would be more appropriate to compare average Point Pleasant withdrawals (56.3 cfs) with average consumptive water losses at the Limerick station (50.7 cfs) to get an indication of expected transit losses. By this calculation, the apparent transit losses would average 5.6 cfs. This is approximately 11 percent of the average consumptive losses at the Limerick station; 11 percent is reasonably close to the estimate of 10-percent transit losses added to the proposed Perkiomen Creek withdrawal of 42 mgd for the purpose of sizing the intake facilities on the Delaware River.

We think the information on water losses is clear enough, and not very critical in the decision on issuing an operating license for the Limerick station.

The DOI, referring to table 4.1 of the Draft EIS, interpreted the table to mean that water will not be drawn from the Delaware River from November through May, and noted that because Schuylkill River flows have dropped below 530 cfs at Pottstown in nearly every month of the year, pumping from the Delaware may be required year-round to meet DRBC requirements.

We interpret table 4.1 to represent an average year, based on the statement on page 4-3 that:

> "Based on historical flow records, the applicant anticipates that virtually all of the water supplied to Limerick to replace consumptive losses...during the period June through October of an average year will come from the Delaware River/Perkiomen Creek System because of the DRBC restrictions. During the remainder of the year, the applicant anticipates that there will be no use of these waters by Limerick." (Emphasis added.)

The DRBC has not assumed that there will never be any use of Delaware River water in the period from November though May for consumptive-use replacement at Limerick, and the DRBC has not imposed any such restriction. The only restriction, which will apply year-round; is that unless compensated by releases from storage, Point Pleasant diversions to Limerick must occur only when the flow of the Delaware River at Trenton exceeds 3,000 cfs.

Actually, November-to-May low flows in the Schuylkill River are not as frequent as might be inferred from the DOI comment. Table 2 shows natural runoff at Pottstown, data developed for the DRBC by the U.S. Geological Survey for the 52-year period from 1923 through 1974. These data are monthly flows ranked from lowest to highest for each calendar month from November through May. For these months, only November and December had monthly flows less than 530 cfs. November flows averaged less than 530 cfs in 7 out of 52 years; December flows in 3 out of 52 years. Based on data for the entire 52-year period (624 months), the median monthly flow was 1,545 cfs. Although these statistics are for monthly flows, they do suggest that winter and spring flows less than 530 cfs are unusual.

As indicated in table 2, water-year 1931 was a very dry period for the Schuylkill River at Pottstown; the monthly flows for this year ranked first (driest) for November, December, and March; second for January; and third for February. It is of interest to know how often during such a dry year the daily flow at Pottstown would be less than 530 cfs. Table 3 lists the daily flows for November through May of water-year 1931. The number of days with flows less than 530 cfs in each month were as follows:

Nov. '30	Dec. '30	Jan. '31	Feb. '31	Mar. '31	Apr. '31	May '31
29	27	18	9	3	0	0

These data indicate that in an extremely dry period like water-year 1931, the use of Schuylkill River water might be prohibited because of low flow as often as 85 days from November through May, or 40 percent of that seven-month period.

For less severe drought periods, the use of Schuylkill River water for replacement of evaporative losses at Limerick would be prohibited less frequently than indicated for 1931. In most years there would be little or no need to prohibit Schuylkill River withdrawals at Limerick except in November. This is supported by tables 4 and 5, which show daily flow data for the Schuylkill River at Pottstown for November through May in relatively dry years. Table 4 shows the number of days on which the flow was less than 530 cfs for the fifth driest calendar month among 52 months with the same name from 1923 through 1974. Table 5 shows the same statistics for the tenth driest calendar month. Daily flows less than 530 cfs occurred on as many as

Table 2.--Schuylkill River at Pottstown, Pa. Ranked Monthly Mean Natural Runoff, November through May--1923 through 1974[a]

Rank	Nov.	Water Year	Dec.	Water Year	Jan.	Water Year	Feb.	Water Year	Mar.	Water Year	Apr.	Water Year	May	Water Year
1	309	1931	419	1931	627	1940	537	1934	1360	1931	1150	1965	725	1965
2	314	1932	434	1923	687	1931	862	1923	1420	1969	1240	1966	739	1941
3	372	1965	528	1932	695	1925	953	1931	1600	1965	1310	1923	810	1926
4	398	1923	604	1929	729	1956	1000	1969	1740	1949	1350	1963	994	1962
5	408	1942	632	1966	878	1966	1120	1944	1950	1934	1360	1925	1010	1955
6	474	1966	650	1961	904	1969	1210	1932	1960	1960	1440	1946	1110	1959
7	507	1937	690	1934	977	1965	1220	1940	1990	1937	1510	1931	1160	1957
8	543	1950	769	1947	985	1970	1270	1963	2040	1957	1580	1971	1170	1935
9	583	1929	805	1967	1070	1923	1330	1967	2070	1959	1610	1968	1190	1969
10	586	1967	835	1940	1100	1942	1350	1946	2200	1968	1630	1942	1190	1963
11	657	1924	840	1944	1120	1948	1490	1924	2220	1970	1680	1926	1200	1938
12	711	1947	909	1965	1140	1954	1510	1954	2290	1932	1740	1927	1240	1951
13	755	1940	939	1956	1190	1961	1750	1947	2340	1938	1810	1938	1300	1930
14	755	1962	971	1964	1320	1945	1780	1955	2390	1973	1820	1967	1420	1936
15	765	1934	986	1962	1320	1955	1820	1964	2390	1947	1980	1954	1430	1939
16	768	1964	1040	1942	1360	1929	1830	1959	2470	1966	2000	1950	1590	1966
17	775	1958	1100	1925	1370	1968	1870	1942	2520	1930	2020	1955	1610	1970
18	812	1945	1100	1948	1490	1963	1870	1941	2600	1928	2050	1941	1630	1925
19	851	1961	1240	1959	1520	1967	2060	1968	2620	1925	2070	1969	1750	1949
20	859	1954	1330	1950	1560	1957	2120	1957	2640	1935	2090	1943	1790	1923
21	883	1925	1380	1930	1580	1933	2170	1930	2670	1941	2220	1945	1790	1934
22	969	1970	1480	1955	1670	1959	2220	1929	2690	1927	2270	1947	1800	1931
23	999	1974	1530	1933	1720	1941	2230	1936	2850	1926	2330	1930	1810	1927
24	1150	1955	1540	1938	1730	1930	2240	1933	2900	1942	2390	1972	1830	1956
25	1270	1969	1580	1963	1730	1944	2280	1938	2910	1974	2430	1959	1880	1932
26	1300	1968	1680	1970	1740	1971	2300	1958	3020	1943	2440	1935	1900	1971
27	1400	1960	1700	1969	1750	1939	2310	1974	3100	1951	2500	1932	1920	1974
28	1430	1949	1730	1936	1770	1926	2370	1948	3170	1964	2560	1956	1920	1937
29	1430	1959	1810	1971	1810	1950	2400	1962	3230	1955	2770	1962	2030	1961
30	1470	1939	1870	1927	1850	1928	2450	1935	3260	1954	2840	1949	2080	1950
31	1710	1935	2040	1945	1900	1932	2480	1927	3280	1950	2850	1937	2110	1968
32	1800	1936	2090	1941	1930	1947	2600	1945	3350	1945	3030	1951	2160	1940
33	1940	1938	2220	1937	1940	1935	2610	1966	3370	1956	3250	1929	2160	1960
34	1960	1930	2390	1926	2200	1927	2700	1972	3380	1946	3320	1964	2170	1944
35	2140	1943	2430	1968	2230	1962	2750	1965	3510	1948	3490	1944	2240	1929
36	2200	1957	2610	1949	2360	1938	2770	1960	3570	1944	3510	1939	2320	1954
37	2240	1946	2910	1946	2390	1934	2920	1956	3590	1939	3530	1961	2680	1967
38	2240	1956	2970	1972	2430	1972	2970	1937	3660	1929	3690	1953	2740	1943
39	2270	1941	3010	1958	2450	1958	3090	1943	3680	1962	3700	1948	2770	1964
40	2330	1928	3140	1954	2540	1960	3110	1952	3810	1961	3910	1936	2850	1928
41	2440	1963	3200	1957	2670	1946	3190	1949	3920	1971	3940	1934	2950	1972
42	2830	1972	3350	1960	2870	1943	3340	1953	3950	1933	3980	1928	3090	1945
43	3060	1948	3360	1943	2880	1951	3560	1961	4130	1967	4000	1960	3100	1946
44	3190	1926	3430	1935	3130	1964	3670	1950	4150	1952	4030	1974	3110	1933
45	3210	1953	3720	1952	3340	1974	3720	1973	4250	1953	4160	1958	3190	1973
46	3220	1944	3780	1939	3410	1936	3740	1970	4250	1972	4580	1957	3320	1958
47	3400	1971	3970	1953	3930	1973	3740	1926	4380	1924	4800	1973	3850	1953
48	3530	1973	4120	1928	4020	1937	4380	1928	4430	1940	4890	1970	4070	1952
49	3720	1952	4190	1924	4270	1953	4560	1939	4590	1958	5150	1933	4450	1948
50	3760	1933	4640	1951	4680	1952	4760	1951	4690	1963	5240	1952	4460	1947
51	3930	1951	4740	1974	4800	1949	5140	1971	5350	1923	5470	1940	4880	1924
52	4210	1927	4880	1973	4830	1924	6920	1925	9010	1936	5510	1924	5380	1942

[a] Source: U. S. Geological Survey. 1975. Natural Flow Project, Delaware River Basin; Prepared for Delaware River Basin Commission, Trenton, N.J.

Table 3.--Daily Flows in Schuylkill River at Pottstown, Pa., November through May, Water Year 1931[a]

Day	Nov. 1930	Dec. 1930	Jan. 1931	Feb. 1931	Mar. 1931	Apr. 1931	May 1931
1	246	300	364	376	578	3270	803
2	288	453	300	349	636	4400	820
3	248	369	260	325	622	3380	873
4	268	314	260	304	564	2980	847
5	249	294	400	299	509	2540	761
6	278	347	2550	309	515	2140	713
7	254	358	1800	320	466	2010	1000
8	258	347	714	226	1290	2080	2660
9	247	336	622	388	3250	1700	3900
10	249	314	593	754	2080	1500	3340
11	254	309	510	605	1490	1380	2830
12	254	260	480	552	1220	1240	2400
13	261	283	440	612	1060	1130	2650
14	276	294	400	1810	976	1050	3900
15	310	213	360	1320	928	986	3470
16	358	200	340	905	910	928	2830
17	392	184	340	1040	1000	882	2400
18	673	294	468	5200	1060	864	2140
19	484	274	1290	2880	1100	794	1820
20	386	273	2070	1600	1170	770	1640
21	358	272	1120	1220	1120	720	1710
22	316	248	678	986	1130	678	1850
23	292	240	562	864	1130	916	1620
24	291	244	523	794	1060	1090	1580
25	310	328	451	736	1130	722	1320
26	317	260	420	674	1290	821	1240
27	300	1330	518	629	1180	1220	1110
28	280	1900	697	600	1100	1120	1000
29	274	976	649	--	3950	948	910
30	302	644	537	--	4350	919	838
31	--	518	426	--	3300	--	829

[a] Source: Pennsylvania Dept. of Forests and Waters. 1933. Stream Flow Records for the Four Years: October 1, 1928, to September 30, 1932; Harrisburg, Pa.

Table 4.--Schuylkill River at Pottstown, Pa.
Daily Flows in 5th Driest Calendar Month,
November through May, for the Period 1922 through 1974[a]

Day	Observed Daily Flows, cfs						
	5th Driest November (1941)	5th Driest December (1965)	5th Driest January (1966)	5th Driest February (1944)	5th Driest March (1934)	5th Driest April (1925)[c]	5th Driest May (1955)
1	445	583	628	1090	420		
2	815	561	668	930	500		
3	756	554	1190	970	1500		
4	510	547	1090	960	5500		
5	460	525	868	890	6500		
6	418	518	1210	815	3730		
7	481	490	1760	779	2400		
8	532	477	1500	738	1820		
9	453	456	1290	676	1500		
10	386	456	1230	607	1430		
11	360	463	1240	648	1220		
12	366	525	964	490	1190		
13	340	665	834	562	1300	No flows less than 530 cfs	No flows less than 530 cfs
14	347	792	919	594	1640		
15	340	712	928	851	1460		
16	314	642	809	1130	1320		
17	295	605	704	1090	1290		
18	295	590	696	1330	1330		
19	293	568	650	2150	1440		
20	302	554	650	1290	1380		
21	314	540	620	1130	1290		
22	308	490	590	1130	1260		
23	416	484	635	1460	1190		
24	541	511	590	1840	1050		
25	492	580	598	1450	1040		
26	399	1070	561	1350	1160		
27	373	866	532	1710	1260		
28	360	704	490	1940	4070		
29	328	673	480	1810	3280		
30	328	635	470	—	2610		
31	—	620	460	—	3400		
Minimum	293	456	460	490	420	889	705
Maximum	815	1070	1760	2150	6500	2077	1560
Mean	412	595	834	1118	1951	1330	1009
No. of days with flow less than 530 cfs[b]	26	11	4	1	2	0	0

[a] Source: U. S. Geological Survey

[b] Minimum flow at Pottstown gage from which make-up water for Limerick power station can be taken from Schuylkill River

[c] Daily discharge data were not available for Pottstown gage; data shown were computed, based on daily flows in the Schuylkill River at Reading, Pa.

Table 5.—Schuylkill River at Pottstown, Pa.
Daily Flows in 10th Driest Calendar Month,
November through May, for the Period 1922 through 1974[a]

Day	Observed daily flow, cfs						
	10th driest November (1966)	10th driest December (1939)	10th driest January (1942)	10th driest February (1946)	10th driest March (1968)	10th driest April (1942)	10th driest May (1963)
1	339	492	No flows less than 530 cfs	No flows less than 530 cfs	No flows less than 530 cfs	No flows less than 530 cfs	No flows less than 530 cfs
2	371	542					
3	436	814					
4	566	731					
5	513	595					
6	423	535					
7	409	513					
8	396	471					
9	396	430					
10	450	450					
11	572	535					
12	632	603					
13	556	535					
14	477	659					
15	429	651					
16	423	572					
17	416	528					
18	423	550					
19	436	520					
20	409	1090					
21	383	2900					
22	377	2080					
23	377	1580					
24	371	1260					
25	377	1020					
26	443	1100					
27	457	980					
28	879	832					
29	2650	868					
30	2030	885					
31	—	772					
Minimum	339	430	650	1020	843	945	822
Maximum	2650	2900	2010	3220	6560	2550	2200
Mean	580	841	1109	1355	2198	1712	1188
No. of days with flow less than 530 cfs	23	5	0	0	0	0	0

[a] Source: U. S. Geological Survey

[b] Minimum flow at Pottstown gage from which make up water for Limerick power station can be taken from the Schuylkill River.

26 days in the fifth driest November and as few as 1 day in the fifth driest February (with none in April or May). For the "tenth driest" category, flows less than 530 cfs occurred on 23 days in November and 5 days in December (with none in the tenth driest January, February, March, April, or May).

Table 6 shows similar statistics for the 25th driest month for each of the seven calendar months from November through May. There were seven days in the 25th driest November (1968) on which the daily flow at Pottstown was less than 530 cfs. There were no such days in the 25th driest December, January, February, March, April, or May.

It should not be inferred from table 6 that daily flows less than 530 cfs occurred in every November drier than the 25th driest November. Because the rankings of months are based on <u>monthly average</u> flows, there can be Novembers drier than the 25th driest November in which the minimum <u>daily</u> flow exceeds 530 cfs. Conversely, there can be minimum daily flows less than 530 cfs in a November ranking wetter than the 25th driest. Table 7 shows the minimum daily flow for each ranked November monthly flow for the 52-year period from water-year 1923 through water-year 1974. Among these 52 Novembers, there were 22 Novembers in which the daily flow was less than 530 cfs on one day or more. The wettest November with daily flows less than 530 cfs was the 32nd driest November.

The streamflow data for the Schuylkill River at Pottstown indicate that the low-flow period--with flows less than 530 cfs--can be expected to extend into November in about 42 percent of the years (22 out of 52). It can be expected to extend less frequently into December. Occasional daily flows less than 530 cfs can occur in any month of the year, but when they occur on scattered days from January through May, they should not be considered as part of the <u>normal</u> low-flow period.

<u>Pumping during low-flow period.</u>--The 1975 DRBC approval of the water supply for the Limerick Generating Station (Docket No. D-69-210 CP--Final) specifies that a minimum pumping rate of 27 cfs shall be maintained during the <u>normal</u> low-flow period. The later (1981) DRBC approval of the Bradshaw Reservoir and its associated pumping station (Docket No. D-79-52 CP--Condition B)

Table 6.—Schuylkill River at Pottstown, Pa.
Daily Flows in 25th Driest Calendar Month,
November through May, for the Period 1922 through 1974[a]

	Observed daily flows, cfs						
Day	25th driest November (1968)	25th driest December (1962)	25th driest January (1944)	25th driest February (1938)	25th driest March (1974)	25th driest April (1959)	25th driest May (1932)
1	499						
2	485						
3	506						
4	506						
5	492						
6	478						
7	513						
8	603						
9	627						
10	864						
11	1190						
12	1390						
13	1520						
14	1280						
15	1170						
16	1400						
17	1700						
18	2200						
19	3200						
20	2700	No flows less than 530 cfs	No flows less than 530 cfs	No flows less than 530 cfs	No flows less than 530 cfs	No flows less than 530 cfs	No flows less than 530 cfs
21	2200						
22	1900						
23	1700						
24	1500						
25	1300						
26	1200						
27	1100						
28	1000						
29	1500						
30	1200						
31	—						
Minimum	478	700	698	1450	1660	1360	1940
Maximum	3200	5370	6560	3550	6220	5630	6350
Mean	1264	1587	1726	2275	2911	2433	3110
No. days with flow less than 530 cfs[b]	7	0	0	0	0	0	0

[a] Source: U. S. Geological Survey

[b] Minimum flow at Pottstown gage from which make up water for Limerick power station can be taken from Schuylkill River.

Table 7.—Schuylkill River at Pottstown, Pa.—
Ranked Mean November Flows and Minimum Daily
Flow for each November, Water-Years 1923 through 1977

Mean November flow Rank (1)	Mean November flow cfs (2)	Minimum daily flow, cfs (3)	No. of November days with flow less than 530 cfs (4)	Water year (5)
1	309	246	29	1931
2	314	240	30	1932
3	372	275	27	1965
4	398	195	30	1923
5	408	293	26	1942
6	474	377	23	1966
7	507	331	22	1937
8	543	428	16	1950
9	583	468	10	1929
10	586	339	23	1967
11	657	403	13	1924
12	711	595	0	1947
13	755	457	10	1940
14	755	403	11	1962
15	765	614	0	1934
16	768	308	18	1964
17	775	391	10	1958
18	812	390	20	1945
19	851	663	0	1961
20	859	476	3	1954
21	883	720	0	1925
22	969	491	2	1970
23	999	734	0	1974
24	1150	477	6	1955
25	1270	478	7	1969
26	1300	656	0	1968
27	1400	803	0	1960
28	1430	502	3	1949
29	1430	753	0	1959
30	1470	971	0	1939
31	1710	1030	0	1935
32	1800	411	10	1936
33	1940	1090	0	1938
34	1960	910	0	1930
35	2140	1250	0	1943
36	2200	1200	0	1957
37	2240	920	0	1946
38	2240	1340	0	1956
39	2270	814	0	1941
40	2330	1050	0	1928
41	2440	1200	0	1963
42	2830	1040	0	1972
43	3060	870	0	1948
44	3190	1040	0	1926
45	3210	620	0	1953
46	3220	1180	0	1944
47	3400	847	0	1971
48	3530	586	0	1973
49	3720	1770	0	1952
50	3760	1640	0	1933
51	3930	686	0	1951
52	4210	1287	0	1927

Source: U. S. Geological Survey

affirms that "The withdrawal of water from the Delaware River at the Point Pleasant Pumping Station for diversion into the East Branch Perkiomen Creek must conform with the schedule and conditions listed in DRBC Docket D-69-210 CP." However, a related new condition (Condition C) in the 1981 approval was that "PECO shall maintain a minimum flow of 27 cfs (17.4 mgd) in the East Branch Perkiomen Creek at the proposed Bucks Road stream gage throughout the normal low-flow period beginning with the day the booster commences pumping and ending when pumping is no longer required for the operation of the Limerick Generating Station. The rest of the year PECO shall maintain a minimum flow of 10 cfs (6.5 mgd)." Thus, during the normal low-flow period, the minimum PECO diversion from the Delaware River to Bradshaw Reservoir will be 27 cfs, and the minimum flow in the East Branch Perkiomen Creek will be 27 cfs as measured at the stream gage at Bucks Road. These are two distinct, though related, requirements. At times when there is measureable natural runoff in the East Branch at Bucks Road, the booster pumps at Bradshaw will not have to move the full 27 cfs from the reservoir into the East Branch.

Pumping during high-flow period.--The DOI asked for clarification of the pumping requirements when the Schuylkill River flow is too low to permit the use of Schuylkill water for make-up of consumptive water use at the Limerick Station during the period from November through May. As explained earlier herein, the low-flow period in the Schuylkill will extend beyond October into November about 42 percent of the years, and when this occurs, the minimum pumping rate of 27 cfs from the Delaware will be required, as well as the Bucks Road minimum flow of 27 cfs. These two minimum rates would prevail until the late fall or early winter when PECO switches back to the Schuylkill River. After that switch, the normal low-flow period will be over, and subsequent occasional Schuylkill flows below 530 cfs will be considered to be occurring in the normal high-flow period. For these low flows during the normal high-flow period, no minimum pumping rate from the Delaware is specified, but a reduced minimum flow of 10 cfs must be maintained in the East Branch Perkiomen Creek throughout the normal high-flow period. Thus, pumping from the Delaware River to meet PECO requirements during the high-flow season will be the greater of two rates: (1) the rate required to maintain a minimum flow of 10 cfs at the Bucks Road gage; or (2) the rate required to meet the Limerick requirement for make-up water plus transit losses.

It should be noted that during the normal low-flow period the required minimum rate of pumping from the Delaware River, 27 cfs, will be greater than the required rate of pumping from Bradshaw Reservoir at times when there is natural runoff in the East Branch Perkiomen Creek as measured at the Bucks Road gaging station. This would tend to raise the water level in Bradshaw Reservoir, and eventually might cause the Reservoir to overflow unless the Delaware River pumping were curtailed. As the purpose of the minimum Delaware pumping rate of 27 cfs was intended only to ensure a minimum flow of 27 cfs at the Bucks Road gage, it would be undesirable and wasteful to continue pumping the full 27 cfs from the Delaware River if 27 cfs could be sustained at the Bucks Road gage with a lesser pumping rate from Bradshaw Reservoir whenever that reservoir is full. Therefore, when the East Branch flow is 27 cfs or greater and Bradshaw Reservoir is full, the pumping of Delaware River water to meet PECO's requirements should be stopped. This will decrease the hazards of impingement and entrainment of aquatic organisms at the Delaware River intake.

In summary, the low-flow period in the Schuylkill River will extend into the month of November in about 22 years out of 52, based on natural flow studies for the period from water-year 1923 through water-year 1974. Much less frequently, the low-flow period will extend into December, during which Pottstown flows will be below 530 cfs on five days in about 10 years out of 52 years--or approximately 1 year out of 5. Occasionally, we may expect these low flows to occur on a few days in calendar months as late as March or April.

When Schuylkill River flows are too low to allow withdrawals for replacement of consumptive use during the period from November through May, the alternative sources will be available for use under the same restrictions and limits as during the period from June through October, even though the need for such restrictions would be generally somewhat less in late fall, winter, and early spring than from June through October. Therefore, the DRBC staff sees no need to be concerned that the low-flow period in the Schuylkill River will in some years extend beyond October, or that occasionally there may be isolated low-flow days in any of the months from November through May.

Water quality

The DOI expressed concern about the quality of Delaware River water to be diverted into Perkiomen Creek.

Sampling.--The DOI observed that the data used by the DRBC and the Pennsylvania Department of Environmental Resources (PADER) were from monthly grab samples and some 24-hour composite samples. The DOI stated that grab samples are inadequate for representing the quality of flowing water, and that only continuous monitoring could achieve the accuracy implied by the DES.

This comment is not consistent with accepted water-quality assessment methods. Continuous monitoring is practical for only a very few water-quality parameters, and continuous monitoring for those parameters is rarely practiced. Generally, the characterization of the quality of surface waters in the United States is based on periodic rather than continuous sampling. The use of the same grab-sample technique in the East Branch Perkiomen and Perkiomen Creeks, as well as in the Delaware River, tends to rule out errors in sampling for purposes of comparing quality in these streams.

Metals.--The DOI stated that although Delaware River water quality has been described as very good, there is evidence of pollution by at least two metals, cadmium and lead.

Concentrations of metals found in the Delaware River at Point Pleasant are generally similar to concentrations found in the East Branch Perkiomen Creek. In some cases, including cadmium and lead, higher concentrations were reported in Perkiomen Creek. Cadmium concentrations ranged from 0.000 to 0.013 mg/l in the East Branch and from 0.000 to 0.010 mg/l in the Delaware River. Lead concentrations ranged from 0.000 to 0.060 mg/l in the East Branch and from 0.000 to 0.020 mg/l in the Delaware. (See Applicant's Environmental Report, tables 2.4-15 and 2.4-16.)

The major source of lead found in surface waters is the atmosphere, which derives most of its lead from the use of leaded gasoline by motor vehicles. The use of leaded gasoline is being phased out gradually, and this is expected to reduce lead concentrations in the atmosphere and in surface waters.

Phosphorus.--The DOI expressed concern that high levels of phosphorus in Delaware River water might cause algal blooms in Bradshaw Reservoir, degrading water quality and causing anoxic conditions in water discharged to Perkiomen Creek.

Anoxic conditions, if they occurred in the reservoir water, would be eliminated quickly by aeration at the energy-dissipation facilities at the outlet of the pipeline discharging into the East Branch Perkiomen Creek. Because of the oxygen-demanding waste load discharged from local sources along the East Branch, any oxygen deficit in that stream is more likely to be caused by these local sources. Rather than increasing dissolved-oxygen deficits in the East Branch or main stem of the Perkiomen, the diversion is expected to improve dissolved-oxygen levels in these streams, especially during the critical warm, low-flow season when dissolved-oxygen levels are most likely to be depressed significantly.

Chemical spills.--The DOI expressed concern that a chemical spill at the Route-32 bridge across Tohickon Creek would travel quickly downstream and be drawn into the Point Pleasant intake, which is only 800 feet downstream of the mouth of Tohickon Creek, thereby contaminating Bradshaw Reservoir, and eventually Perkiomen Creek.

Any chemical spill from the Route-32 bridge would be subject to dilution in Tohickon Creek and in the Delaware River before reaching the Point Pleasant intake. Additional dilution by mixing would occur in Bradshaw Reservoir. On the other hand, the East Branch Perkiomen Creek is crossed by Routes 313, 152, 309, 63, the Northeast Extension of the Pennsylvania Turnpike, and the Reading Railroad. Chemical spills at these crossings--some of which are much more heavily traveled than the Tohickon crossing--would receive less dilution than spills reaching the Delaware, and the diversion of Delaware River water into the East Branch would provide dilution of the chemicals spilled locally. In fact, the existence of the diversion facilities would make it possible to dilute local spills beyond the level provided by the flow augmentation of Perkiomen Creek and its East Branch for Limerick water supply alone, if in an emergency this were desirable.

Environmental consequences

Percentage withdrawal.--The DOI states that to calculate the highest possible percentage of the Delaware River flows that would be withdrawn by Limerick, a flow of at least 3,000 cfs is assumed to be maintained at Trenton, and notes that flows less than 3,000 cfs are not uncommon in the USGS gaging records. The DOI notes that the Trenton flow dropped to 1,900 cfs in January 1981, and states that the extremes most significantly affect fish and wildlife resources.

It is somewhat misleading to cite observed historical flows in a regulated stream for which the degree and method of regulation will be different in the future. Nevertheless, under the recently adopted reservoir operating rules for basin reservoirs in future droughts (DRBC Resolution 83-13, June 1983), the regulated flow objective for the Delaware River at Trenton will be as low as 2,500 cfs. This is indeed less than 3,000 cfs. However, the DRBC has prohibited Delaware River withdrawals for the Limerick station when such withdrawals would result in Trenton flows less than 3,000 cfs. The base flow to be used in calculating the percentage of river flow withdrawn at Point Pleasant depends on the purpose of the calculation. If the purpose is to assess the effect on the river flow at Trenton, the flow of 3,000 cfs should be the base flow used. For Trenton flows less than 3,000 cfs, withdrawals for Limerick will be made only if compensated gallon for gallon by releases from upstream storage, and there will be no reduction of the Trenton flow. However, if the purpose is to assess the potential for impingement or entrainment, for example, at the Point Pleasant intake, then the percentage calculation should be the river flow at the intake that is equivalent to a Trenton flow of 2,500 cfs. Based on drainage area, the equivalent Point Pleasant flow is 2,425 cfs. This is an interim low flow until scheduled additional storage capacity increases the sustainable flow (modifications of Walter and Prompton Reservoirs to provide water-supply storage.)

The occurrence of the low flows in January 1981 have been discussed earlier herein under the heading "Surface water hydrology." In the context of considering the percentage of the Delaware River flow withdrawn for the

Limerick project, such low Delaware flows are relevant only if simultaneous with Schuylkill River and Perkiomen Creek low flows that would trigger a switch from the Schuylkill River, or Perkiomen Creek, as the source of make-up water, to the Delaware River. The Schuylkill flows in January 1981 were too low to permit make-up withdrawals; the maximum daily flow at Pottstown was only 490 cfs. Also, the flows in the Perkiomen Creek at Graterford were too low to serve Limerick. Therefore, in a recurrence of these circumstances, the Delaware River would be the source of make-up water for the Limerick Station, assuming it was operating.

It should be noted that the hydrologic conditions of January 1981 were of record-breaking rarity for dry winter periods. Concern about low flows like those of January 1981 should be tempered with recognition of their rarity.

As noted elsewhere herein, the Trenton flows below the objective flow were not indicative of the flow capability of existing reservoirs; the observed deficient flows were the result of difficulty experienced by the Delaware River Master in scheduling reservoir releases to meet the flow objectives at Montague. The deficiences could have been made up by releases from lower-basin reservoirs controlled by the DRBC, but in view of the season--with minimum stress on aquatic life--the DRBC deemed it more prudent to conserve water in storage except as needed for controlling salinity in the Delaware estuary.

With the 1983 adoption of the rules for reservoir operation (DRBC Resolution 83-13), the likelihood of future flows less than the objective flows specified in these rules has been reduced. The DRBC will continue to confer with the River Master to encourage the scheduling of releases to meet the specified objectives.

In spite of everything, occasional Delaware River flows below the flow objectives cannot be ruled out. If such flow deficiencies occur in the future, withdrawals for Limerick will have varying environmental impacts depending on various factors. These include the seasonal factors, such as water temperature and the cyclic stage of living organisms present. The withdrawal of Delaware River water at the maximum rate planned would have little or no environmental consequences in January, even assuming Delaware flows as low as 1,900 cfs at Trenton.

Enforcement of withdrawal conditions.—The DOI suggests that the statement in the DES to the effect that Limerick will not be permitted to withdraw water from the Delaware River when the flows at Trenton fall below 3,000 cfs is unrealistic. DOI's reason is that the DOI is unaware of a single instance when the DRBC has required anyone to stop withdrawing water because of low flows at Trenton.

It should be noted that the DRBC prohibition against the Delaware River withdrawals for Limerick when the Trenton flow is less than 3,000 cfs applies only if the withdrawals are not replaced by releases from storage (i.e., from Merrill Creek or an alternative project). PECO is a participant in the proposed Merrill Creek Reservoir project, which is currently being planned to provide such releases from storage. If the Merrill Creek project is built, it will preclude the necessity for curtailing withdrawals from the Delaware for the Limerick Station.

As the Secretary of the Interior has been a member of the DRBC since its inception, the DOI should be aware that on two occasions, in the droughts of 1965 and 1980-81, the DRBC invoked its emergency powers to curtail withdrawals from the Delaware River, especially out-of-basin diversions. With the adoption of Resolution 83-13, the DRBC has made it clear that similar restrictions on withdrawals can be expected in future periods of low flows in the Delaware.

Even if the DRBC had not used its power to limit withdrawals in past drought periods, it would not follow that the DRBC would fail to enforce the conditions specified for the Limerick withdrawals from the Delaware. Waiving these conditions would require the approval of a majority of the five DRBC members (one of which is the Secretary of the Interior) or their representatives.

The Limerick project was the first project approved by the DRBC for which water use from the Delaware River was conditioned upon a minimum river flow. This condition was specified in the original approval of Limerick water use in

1973. The fact that there has been no DRBC enforcement of the withdrawal condition means only that there has been no occasion to enforce it--and there will be no such occasion until the Limerick project is completed and operating during a period of low flow in the Delaware River.

The will of the DRBC to enforce its rules is exemplified by fines that have been levied against violators, some of whom were found to be exceeding the withdrawal limits specified by the DRBC. The DRBC has a record of enforcing its rules.

Cumulative impacts of withdrawals.--The DOI erroneously states that cumulative impacts of water withdrawals in the Delaware Basin have been ignored, and suggests discussing the combined effects of over-allocating water in the Basin; diversions of water to New York City and northeastern New Jersey; over-pumping ground water; excessive consumptive withdrawals; and the lack of adequate make-up water storage in the Basin on salinity intrusion in upper Delaware Bay.

These factors have not been ignored. All of them, as applicable, have been considered and taken into account in the deliberations leading to the DRBC approval of the Limerick water supply. These factors should not be considered by themselves; they must be--and have been--considered in conjunction with all other relevant factors, including the availability of storage impoundments making releases to offset the out-of-basin diversions, releases from existing storage to offset current consumptive use within the Basin and to control salinity in the estuary; and planned new storage capacity to offset projected increases in consumptive use and to increase the ability to control salinity. Taking all relevant factors into account reveals that the water supplies of the Basin are not currently over-allocated, and scheduled construction of new impoundments would offset projected increases in consumptive use to the year 2000.

It should be noted that the question of over-allocation of water supplies would be relevant to the decision on issuing an operating license for the Limerick station only if there were no restrictions on the use of water for that station. However, these restrictions fully reflect the expected shortage of water during low-flow periods. For example, when there is a shortage of water in the Delaware River (i.e., when the Trenton flow is less than 3,000 cfs), no diversion will be permitted for the Limerick station unless such diversion is replaced by releases from storage.

Salinity modeling.--The DOI erroneously states that simulations with the Thatcher-Harleman salinity model of the Delaware estuary have never taken into account the reduced flows from over-pumping ground water in consumptive-use estimates. The salinity model implicitly accounts for ground-water pumpage as of 1965--the drought year for which the model was calibrated--through the calibration process. The observed fresh-water inflows to the estuary in 1965, which were used in calibrating the model, reflected all ground-water pumping and consumptive use of ground water within the Basin at that time. Post-1965 increases of consumptive use, including consumptive use of both ground and surface water, have been accounted for explicitly by subtracting these consumptive uses from the fresh-water inflows to the Delaware estuary.

The DOI erroneously refers to the Potomac-Raritan-Magothy (PRM) aquifer system as an aquifer. It is not a single aquifer, but a group of interconnected aquifers.

The DOI states that the PRM aquifer [system] underlies the Delaware River south of Camden. This is true, but the PRM system underlies the river north of Camden also, and it is the area upstream of Camden--specifically, upstream of river-mile 98 in Camden--that is considered critical with respect to aquifer recharge by the tidal river.

The DOI states correctly that because of heavy pumping of the PRM aquifer system, lowered water tables have caused water from the Delaware River to flow into the ground water. This is apparently the basis for the DOI statement earlier in the same paragraph that the salinity model has not taken into account the reduced flows from over-pumping ground water, which statement, as explained above, is in error.

The DOI assumption that over-pumping ground water from the PRM aquifer system has reduced river flows is subject to question and clarification.

Much, if not most, of the water pumped from the ground in the vicinity of the tidal Delaware River, thereby lowering the "water table" (or piezometric surface) of the aquifer system, is not used consumptively, and the nonconsumed water is discharged to the tidal river via waste-water collection and treatment systems. Thus, much of the aquifer recharge from the river is returned to the river, and only the consumptive use has to be accounted for in modeling estuary salinity. As already explained, the consumptive use has been accounted for in the DRBC simulations with the Thatcher-Harleman salinity model.

The DOI states erroneously that the DRBC salinity model assumes a minimun flow of 2,700 cfs. The model has been used to simulate a wide variety of conditions, including regulated dry-season Delaware River flows at Trenton ranging from 2,000 cfs to 4,000 cfs, with year-round variation in accordance with the observed flow regimen.

The DOI erroneously states that adequate storage does not now exist in the basin to maintain target flows at Trenton. As explained earlier herein, the DOI is apparently confusing observed flows with sustained-flow capability. The currently existing storage capacity in the Basin is adequate to meet the current target flow. However, to keep ahead of projected increased needs for sustained flows at Trenton, new storage capacity will be needed--and is being planned.

The DOI states that the progressive decrease in fresh-water input and rising sea level has resulted in higher salinity levels in Delaware Bay. Although there is strong evidence that a rising sea-level trend has contributed to higher salinity in the bay, there is no clear evidence that a <u>progressive</u> decrease in fresh-water input has resulted in significantly higher salinity levels in Delaware Bay in the past. The highest observed salinities in the estuary occurred during the unprecedented severe drought of the 1960s, and resulted from record low fresh-water inputs over an extended period. However, this cannot be classified as a <u>progressive</u> decrease in fresh-water input; it could have occurred decades earlier under similar drought conditions with similar salinity results, regardless of any other salinity-increasing factor, such as increasing depletive water use.

Of course, there has been a progressive decrease in fresh-water inputs to the Delaware estuary, but that decrease was relatively insignificant before the 1965 drought when compared to the natural cycle of runoff, even the average annual cycle, and especially when compared to the great range of fresh-water inputs accompanying floods and droughts.

Salinity over seed-oyster beds.--The DOI cited a 1972 study by Dr. Harold H. Haskin, Professor of Zoology and Shellfish Investigations at Rutgers University. This study, according to DOI, showed significant increases in salinity at five locations in Delaware Bay over a 41-year period. This 1972 study, sponsored by the DRBC, was based on empirical correlations between observed antecedant mean 30-day flows of the Delaware River at Trenton and salinity at given locations over seed-oyster beds in the upper bay. The correlations ignored all inputs or subtractions of fresh water seaward of Trenton. This and other shortcomings of such empirical correlations led to the development of the DRBC (Thatcher-Harleman) mathematical model of salinity distribution in the Delaware estuary. It appears ironic that after criticizing the DRBC salinity model on the mistaken DOI assumption that it did not account for reduced fresh-water inflows below Trenton resulting from pumping ground water, the DOI would cite as evidence the Haskin correlations--which did not take into account any fresh-water inputs or subtractions from either surface or underground sources seaward of Trenton. With the availability of the state-of-the-art Thatcher-Harleman salinity model, inconsistencies between the results of the Haskin correlations and those of the DRBC salinity model should be resolved in favor of the latter.

The DOI appears to have misinterpreted the results of Dr. Haskin's study. According to the DOI, Dr. Haskin showed significant increases in salinity at five locations in Delaware Bay over a 41-year period. Haskin presented flow-salinity correlations for two time periods: from 1927 through 1952 and from 1953 through 1968. He did report "... a tendency toward increased salinity with a given river flow." However, that tendency did not hold for the higher salinities and the corresponding low river flows; at all five locations studied, the higher salinities for the 1953-1968 period were lower than the pre-1953 salinities for a given river flow. Figure 1, taken from Haskin (1972), clearly shows this phenomenon. Since it is the high salinities that

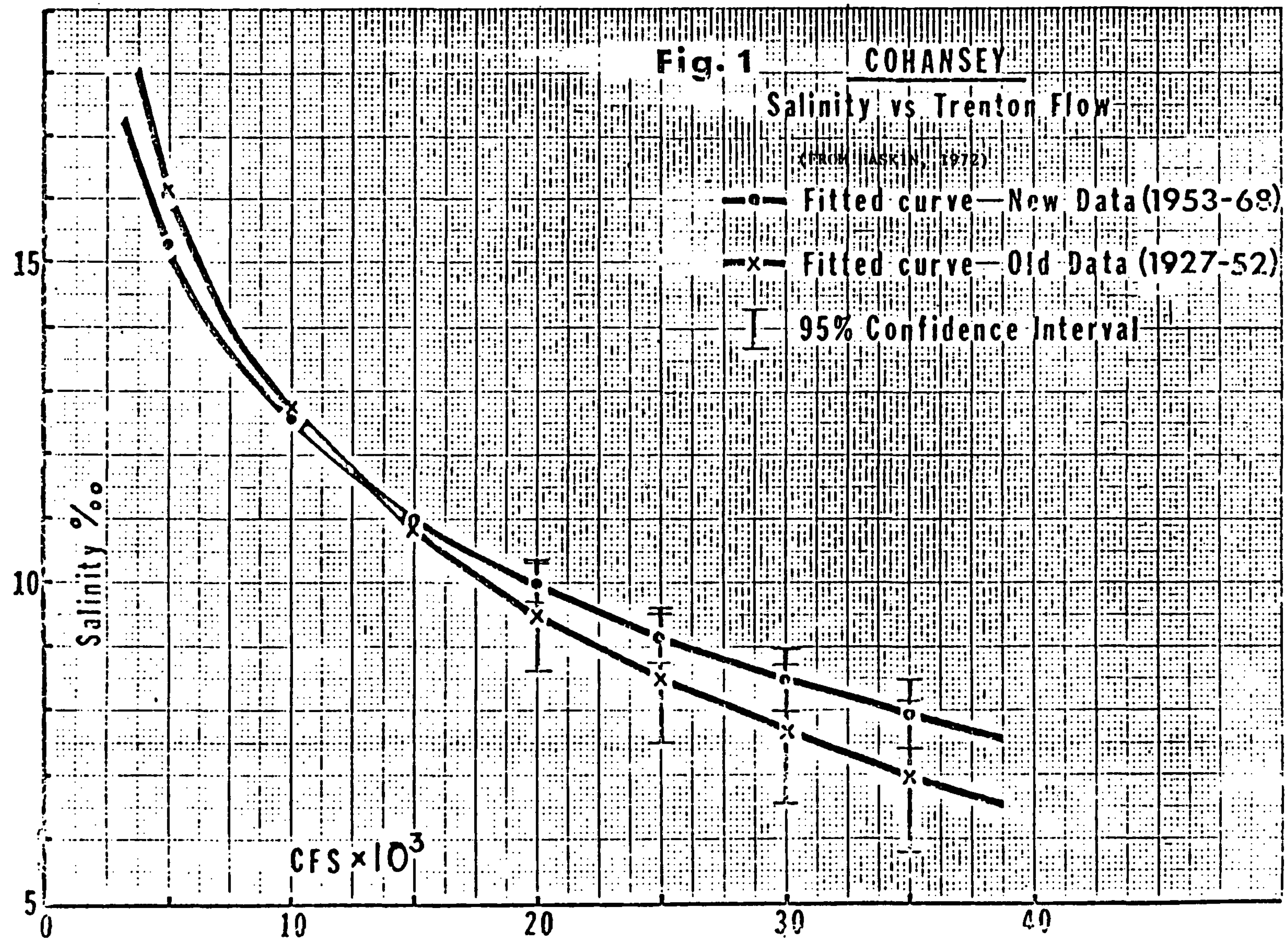
Fig. 1
COHANSEY
Salinity vs Trenton Flow
Fitted curve—New Data (1953-68)
Fitted curve—Old Data (1927-52)
95% Confidence Interval
Salinity ‰
CFS × 10³
5
10
15
0
10
20
30
40

are of concern with respect to oyster protection, the Haskin study results suggest that post-1952 salinity conditions are more favorable to oysters than pre-1953 salinity conditions. This is opposite to the conclusion reached by the DOI from Haskin's report.

The principal conclusion reached by Haskin (1972) was that the salinity-flow relationships for the second period differ from those of the first period. That is, for a given river flow at Trenton, the salinities for the two periods differed. This indicates that some factor other than the river flow at Trenton had changed from the first period to the second. Haskin stated that the cause of the shift in the salinity-flow relationship was unknown, but suggested tnree possibilities, as follows:

1. A shift in the ratio of fresh-water supply to the Bay area between sources above and below Trenton.

2. Changes in bottom topography in the estuary (by erosion or dredging).

3. Changing sea level.

With respect to the first factor, Haskin stated that if the observed shift is related to a change in fresh-water supply, it would require a reduced fresh-water supply below Trenton for a given river flow at Trenton. This is a correct observation for most of Haskin's data, but, as noted above, his data for low river flows and corresponding high salinities show an opposite shift in the salinity-flow relationship, which would require an increased fresh-water supply below Trenton for a given river flow at Trenton.

It is quite possible, if not probable, that all three factors suggested by Haskin (1972) have contributed to the apparent shift in the salinity-flow relationship for the Delaware estuary. Most of the increase in depletive use within the Delaware Basin has occurred in that part of the Basin below Trenton. There has been channel deepening and other dredging, and sea level has followed a rising trend for many decades. Simulations with the DRBC salinity model have shown that rising sea level significantly increases salinities throughout the Delaware estuary.

Another factor, later suggested by Haskin (1975), that would tend to change the correlations between Trenton flows and Bay salinities is modification of the Chesapeake and Delaware Canal. Such modification has been carried out; the canal was enlarged between 1963 and 1975, which overlaps the second period analyzed by Haskin, from 1953 through 1968. The partial enlargement by 1968 may have influenced Haskin's second-period results. Recent studies with the DRBC salinity model have shown that the canal generally reduces salinities in the middle reach of the Delaware estuary, including the upper portion of Delaware Bay. This is consistent with Haskin's observations for low-flow, high-salinity conditions, but not for his observations for high-flow conditions when intermediate or low salinities are found over the seed-oyster beds.

Haskin (1972) did not show the dates for which the salinities were observed. The higher salinities are usually observed in late summer or fall of dry years. However, it is the period from May through mid-July that is critical with respect to protection of the seed oysters from enemies that are favored by high salinities.

Nothing in the 1972 Haskin report supports any concern that the diversion of water from the Delaware River above Trenton for consumptive use at the Limerick generating station would increase salinity over the seed-oyster beds of upper Delaware Bay. In fact, Dr. Haskin (1983) has recently responded to allegations that the Point Pleasant diversion would adversely affect the oyster industry of Delaware Bay. In a letter to the Managing Editor of Del-Aware Citizens Voice, a periodical opposing the diversion, Dr. Haskin stated in part:

> "You write that the U.S. Fish and Wildlife [Service] 'report(s) that increased salt in the estuary, is ruining the oyster and shellfish industries,' implying that the Point Pleasant diversion would adversely affect the oyster industry of Delaware Bay. This is incorrect. The New Jersey oyster industry is holding its own despite pressure from predators and MSX problems. Production is rising, and this past year quality has been excellent."

After noting that the critical requirement for protection of the seed oysters is natural river flows from April first into early summer, Dr. Haskin stated further, as follows:

> "If you are implying in your comments that the Point Pleasant diversion would cause salinity problems for the oyster industry, this is wrong. The permitted 95 mgd diversion is not all depletive use. Roughly 90% of the public water supply returns to the river at or above the Schuylkill. If both Limerick plants were operating, that would mean a total depletive use of roughly 50 mgd (75 cfs). At the critical time of year for the oyster seed beds, average annual Trenton flows are: April, 23,369 cfs; May, 13,730 cfs; and June, 8,011 cfs. A change of 75 cfs would not be measurable down on the seeds beds. Furthermore, by the time the fresh water [from Trenton] reaches the uppermost of the natural oyster seed beds, additional fresh water inflow below Trenton has increased the ratio of water to 1.6 times the Trenton flow, further minimizing the effect of a 75 cfs depletive use upriver."

Rising sea level.—The DOI referred to a 1979 preliminary draft of a DRBC report on the effect of rising sea level on salinity in the Delaware estuary. The preliminary draft, as noted by the DOI, indicated a need for more freshwater input to the estuary to maintain existing salinity regimes in Delaware Bay. The DOI indicated that this need amounted to incremental flow needs of from 3 to 10 cfs per year. Actually, the preliminary draft indicated that a 35-year incremental flow augmentation of 340 cfs would be needed to offset the expected total rise in sea level from 1965 to the year 2000. This was based on preliminary simulations with the salinity model in which tide data were estimated for the last three months of the fifteen-month period simulated. These three months were critical because they coincided with the period of peak salinity intrusion. Later, the observed tide data for these three months were obtained and used in a new 15-month simulation, and the results were significantly different. The corrected tide inputs resulted in a finding that, instead of 340 cfs, only 150 cfs would be needed to offset the projected 35-year rise in sea level (Hull and Tortoriello 1983). This amounts to about 4.3 cfs per year, which is the best available estimate; this value should be used instead of the range of from 3 to 10 cfs given by the DOI.

It should be noted that the DRBC projected the year-2000 sea level on the basis of past trends, and the estimated flow-augmentation need to offset the salinity-increasing effect of the rising sea level did not reflect an accelerated sea-level rise that is currently being considered by some investigators.

The question of rising sea level would be pertinent to the licensing of the Limerick station only if that station would reduce the critical low flows of fresh water into the estuary. However, the need to consider sea level has been obviated by the DRBC permit for water use at Limerick, which limits the withdrawals for consumptive use from the natural runoff to periods of relatively high streamflows, when salinity control in the estuary is not critical.

Dissolved oxygen in estuary.—The DOI notes that the DRBC water-quality model for the Delaware estuary shows a direct relationship between river flows and dissolved oxygen levels in Zone II of the Delaware estuary, which covers the reach from the head of tide at Trenton (river-mile 133.37) to Riverton, N.J. (river-mile 108.40). The DOI states that water withdrawn at Point Pleasant will bypass all but three miles of Zone II, implying that this would lower dissolved oxygen concentrations in Zone II. However, the DRBC permit for Limerick water use requires that when the flows are critically low at Trenton, the withdrawals at Point Pleasant must be replaced gallon for gallon by releases of water from storage. Therefore, the Point Pleasant withdrawals for Limerick will not reduce the critical low flows (those less than 3,000 cfs) at Trenton.

In considering the effect on river flow as related to Zone II oxygen conditions, it is necessary to consider the cumulative net effect of all developments, not just the Limerick withdrawals. Since the drought of the 1960s, the capability of Trenton flow maintenance has been doubled by the construction of new reservoir capacity and the development of operating rules for existing impoundments. Additional reservoir capacity is planned for future development, which will further improve oxygen conditions in Zone II. For example, Merrill Creek Reservoir is being planned as the source of the releases to replace consumptive water use at the Limerick station, as well as at 14 other generating units, some of which are located seaward of Zone II. Therefore, the releases for these seaward stations will augment the low flows through Zone II, thus improving the dissolved-oxygen conditions for the benefit of fish migrating through the upper estuary. This benefit will extend beyond Zone II. Also, the efficiency and reliability of waste-treatment facilities discharging effluents into Zone II have been upgraded.

Water quality in East Branch Perkiomen.--The DOI expressed concern about potential nuisance algal blooms and plant growth in the East Branch of Perkiomen Creek--because of observed orthophosphate concentrations of from 0.01 to 0.75 mg/l in the Delaware River 25 miles upstream of the Point Pleasant intake. The DOI stated that with a short detention time in Bradshaw Reservoir, up to four times the level of organic phosphates could be discharged to the East Branch.

The East Branch has an average gradient of about 11 feet per mile, which means that it is a fast moving stream, especially with a minimum regulated flow of 27 cfs at the control gage near the head of the stream during low-flow periods. Such rapidly flowing streams are not conducive to nuisance algal blooms or plant growth. During the normal high-flow periods when the minimum flow at the Bucks Road gage will be 10 cfs, temperatures and sunlight are not such as to support nuisance algal or plant conditions.

Moreover, the East Branch throughout most of its length already has higher phosphate concentrations than the Delaware River at Point Pleasant. These high concentrations result from industrial and municipal waste discharges from the Perkasie, Sellersville, and Telford areas, and runoff from farmland and urban areas. As noted in the DES (page 4-31), nutrient levels are excessive in the middle reaches of the East Branch. At the lower East Branch sampling station (E2800), nutrient concentrations remained high, with average phosphate levels about an order of magnitude greater than those of the upper East Branch sampling station.

The DRBC staff is of the opinion that the water-quality characteristics of the East Branch Perkiomen Creek will be generally improved by the added flow diverted from the Delaware River. This improvement will include a reduction of average phosphate concentrations in the middle and lower reaches of the East Branch. This is especially true for the critical low-flow period of the year, when the augmented flow as measured at the Bucks Road gage will be not less than 27 cfs.

Aquatic resource impact summary

The DOI erroneously states that when the Limerick project was originally planned, the DRBC assumed that existing storage capacity was available. The initial DRBC approval of the project recognized the inadequacy of the then existing water-storage capacity, and the approval was conditioned upon the operation of the generating facility only to the extent supported by available streamflow or by future water-supply storage capacity to be developed by the DRBC or--in the absence of DRBC storage--by the applicant.

The DOI erroneously states that recent droughts have demonstrated that existing storage capacity cannot even meet current water demands. The fallacy of this statement has been explained earlier herein.

Merrill Creek project.--The DOI recommended that the DES be revised to discuss environmental impacts of the Merrill Creek Reservoir project, which is being planned as a source of water to replace consumptive water losses at the Limerick station and other generating plants. A separate Draft Environmental Impact Statement on the Merrill Creek project has been prepared by the DRBC, and a Final Impact Statement is currently nearing completion.

The rationale for separating the Merrill Creek project from the Point Pleasant diversion for purposes of environmental review and impact-statement preparation is addressed in the Draft EIS for the Merrill Creek project. This issue was addressed by the U. S. District Court in Delaware Water Emergency Group et al. v. Gerald M. Hansler, et al. and Neshaminy Water Resources Authority and Philadelphia Electric Company, No. 80-4372, August 17, 1981. The Court found that the Merrill Creek Reservoir was "...not required...nor an essential or necessary adjunct..." to the Point Pleasant project application.

The environmental issues related to the Merrill Creek project raised by the DOI will be addressed in the Final EIS on that project, to be issued by the DRBC.

The DOI recommended that less environmentally damaging make-up water storage options in the Schuylkill River Basin be seriously considered as alternatives to the Merrill Creek project. Alternatives to the Merrill Creek are discussed in the Draft EIS on the Merrill Creek project, and will be discussed further in the Final EIS being prepared by the DRBC.

Unavoidable adverse impacts

The DOI states that the DES does not adequately address impacts of the Limerick project on fish and wildlife resources, and that the DES does not reflect the most recent information pertaining to these impacts. The DOI states that the impact assessment of the Point Pleasant diversion relies heavily on data previously prepared by the DRBC, and the DOI believes that assumptions used by the DRBC in the original models to generate these data are no longer valid, based on the most recent information available.

The DRBC staff is not aware of any recent information that would change the impact assessment of the Point Pleasant diversion. Perhaps the DOI reference to assumptions used in the DRBC models is based on the DOI's mistaken assumption that the DRBC salinity model does not account for reduction of fresh-water flow into the estuary caused by ground-water pumping from aquifers hydraulically connected with the estuary. This erroneous DOI assumption has been discussed earlier herein.

Water quality in estuary.--The DOI states that the potential exists for cumulative adverse impacts to water quality in the Delaware estuary and for increased salinity intrusion in upper Delaware Bay. The DRBC prohibition against diversion of Delaware River water for use at Limerick when the Delaware River flow at Trenton is less than 3,000 cfs adequately protects the general water quality of the Delaware estuary. The DOI concern about increased salinity in upper Delaware Bay has been addressed earlier herein under the heading "Environmental Consequences."

Water quality in Perkiomen Creek.--The DOI states that water quality may be degraded in Perkiomen Creek during diversions from the Delaware River. The DRBC staff does not believe that Perkiomen Creek water will be degraded by the diversion. We believe that the low-flow augmentation to be provided by the diversion in both the East Branch and the main stem of Perkiomen Creek will generally improve the quality of these streams, now degraded by discharges of sewage and industrial wastes and contaminants from non-point sources.

Entrainment and impingement.--The DOI states that a potential exists for entrainment and impingement of eggs and larval fishes at the Point Pleasant intake. The entrainment and impingement problem has been minimized by relocation and state-of-the-art redesign of the intake in accordance with suggestions from the U. S. Fish and Wildlife Service and the Pennsylvania Fish Commission.

Class 9 accident.--The DOI states that the potential for impacts on ground-water resources as a result of a Class-9 accident involving penetration of the basemat by reactor core debris is especially worthy of analysis at the Limerick site, because the Brunswick aquifer is characterized by secondary permeability derived largely from vertical joints, as noted on page 4-22 of the DES. This permeability may permit relatively rapid movement of contaminants in ground water in the event of a melt through the basemat and escape of contaminants.

Evaluation of Class-9 accidents is the responsibility of NRC, not DRBC. The DRBC staff notes that the DES states in its "Summary and Conclusions" (page viii, subsection 4(s)) that the plant-specific review of the Limerick probabilistic risk assessment analysis of severe accidents is not complete, and that the NRC staff's analysis of the environmental impacts of postulated plant accidents will be provided in a supplement to the DES. On page 5-b, the DES states that the results of the NRC staff evaluation of the environmental impacts of postulated accidents will be published as a supplement to the DES and will be available for public comment.

Fish and Wildlife Coordination Act

The DOI states, in its letter dated August 26, 1983, that its comments presented therein do not preclude separate evaluation and comments by its subagency, the Fish and Wildlife Service (FWS), pursuant to the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), since the proposal to construct the dam and water intake structures will require Section 404 permits from the Corps of Engineers. However, the Corps of Engineers had already issued the Section 404 permits for construction of the water intakes well before the Draft Environmental Statement related to operation was issued by the NRC in June 1983. Moreover, there is no dam requiring a section 404 permit in the Limerick project. Perhaps the DOI is referring to the intake and dam associated with the Merrill Creek Reservoir project, which is a separate project for purposes of environmental review.

As already noted herein, the economic feasibility of the Limerick Generating Station does not depend on the Merrill Creek project. Also, the latter project is designed to provide water supply for 14 generating units in addition to Limerick Units 1 and 2, and therefore, the Merrill Creek project would be needed even if not used to supply water for Limerick.

Point Pleasant

The DOI noted that on October 18, 1982, the Fish and Wildlife Service recommended denial of the Department of the Army construction permit to the Neshaminy Water Resources Authority. However, the permit was subsequently issued, and the permit question was moot at the time of the DOI comments to the NRC in August 1983.

The DOI cites several reasons why the FWS recommended denial of the section 404 permit for the Point Pleasant diversion. This project has been subjected to thorough environmental review by the DRBC and the Corps of Engineers, and the adequacy of these reviews has been affirmed by the U. S. District Court. All necessary approvals by the DRBC have been granted, and the section 404 permit has also been issued. The DOI's purpose in raising a question pertaining to construction permits for the Point Pleasant diversion in August 1983 is not clear.

Delaware Bay salinity.—Under the heading of the "Point Pleasant" project, the DOI presents as FWS arguments the same salinity-related comments presented earlier in the DOI letter in discussing the Limerick station DES. The validity of these DOI comments has been reviewed already in these DRBC staff comments.

Estuarine dissolved oxygen.—The arguments related to dissolved oxygen presented by the DOI as FWS reasons for its recommendation for permit denial for the Point Pleasant diversion are essentially the same as the earlier DOI comments on the Limerick station DES. The validity of these DOI comments has been reviewed already in this paper.

Impacts on North Branch Neshaminy Creek and East Branch Perkiomen Creek.—The DOI presents an FWS allegation that increased discharges to both the North Branch Neshaminy Creek and the East Branch Perkiomen Creek will scour stream banks and stream bottom, increasing turbidity and sedimentation downstream. Only the East Branch Perkiomen Creek is involved in the Limerick application. Both creeks have been considered by the DRBC in its court-approved environmental reviews of the Limerick water supply project and the Neshaminy public water supply system. The NRC DES, on page 5-31, reviews the DRBC conclusions about the environmental impacts of the diversion of Delaware River water (pages 33-35 and 44 of the DRBC EIS of 1973). These court-sanctioned conclusions provide an adequate response to the FWS allegation. It is noteworthy, however, that the DOI concern about increased discharges and turbidity is inconsistent with the DOI concern about nuisance algal blooms and plant growth in the East Branch.

Lake Galena.—The DOI presents an FWS allegation that increased phosphate loading of Lake Galena will accelerate eutrophication and cause water quality problems.

Lake Galena is not part of the facilities required for supplying water to the Limerick generating station; it is part of the public water-supply system being developed by the Neshaminy Water Resources Authority. The Neshaminy Water Supply System was covered by separate environmental reviews. These reviews have been approved by the Federal courts.

Cadmium and lead.--The DOI cites an FWS allegation that Delaware River water diverted to the East Branch Perkiomen Creek and the North Branch Neshaminy Creek will degrade water quality in both streams by introducing higher levels of cadmium and lead.

The diversion to the North Branch Neshaminy Creek has been subjected to a separate court-approved environmental review and all permits have been issued.

The FWS concern regarding the introduction of higher levels of cadmium and lead into the East Branch Perkiomen Creek appear to be identical to the DOI concern, to which we have responded earlier herein.

Ground-water contamination.--The DOI cites an FWS allegation that the diverted Delaware River water would contaminate ground-water aquifers that are recharged by Perkiomen Creek.

As previously noted herein, the incremental increase in wetted streambed or hydraulic head caused by augmenting the flow of Perkiomen Creek would be very small, and therefore would not cause a significant increase in the loss of water from Perkiomen Creek to the nearby aquifers. Moreover, the quality of the Delaware River water diverted will be significantly better than the quality of the water in the middle and lower reaches of the East Branch Perkiomen Creek. Therefore, the quality of the water flowing from the East Branch into the main stem of Perkiomen Creek will be improved by dilution. Aquifers recharged by Perkiomen Creek would receive better quality water from the Creek when the Delaware River water is diluting the contamination that reaches the creek from other sources.

Impacts at intake site.--The DOI cites an FWS allegation that the pipeline from the Delaware River to the pumphouse at Point Pleasant will disturb one acre of riverine, forested wetland and permanently destroy 0.3 acre.

This impact was recognized in the environmental review of the Point Pleasant facility, which has been completed and approved by the courts. All permits have been issued and construction is underway. The impact of the pipeline would not be changed significantly if the Limerick project were not licensed to operate. Therefore, the impacts of that pipeline on the local area are not relevant to the decision on the Limerick operating license.

Delaware River eddy.--The DOI cites an FWS concern that the Delaware River intake is at the edge of a large back eddy in the river below Tohickon Creek; and that at low flows the intake will be in this eddy, which is a spawning and nursery area for various species of fish.

The intake has been reviewed and approved and all necessary permits have been issued based on total diversion rates that include the water supply for Limerick, and construction is underway. If the Limerick diversion rate were subtracted from the total approved rate, the hazard to fish eggs and larvae would remain, but would be reduced somewhat. It should be noted that in approving the Point Pleasant diversion from the Delaware River, the DRBC required that the applicant, the Neshaminy Water Resources Authority, monitor the operation of the intake facilities and take mitigating steps as necessary.

Merrill Creek Reservoir.--The DOI cites an FWS concern that the Merrill Creek Reservoir project, which was partly justified by the Point Pleasant Diversion, would have various impacts on fish and wildlife.

The FWS concerns about the Merrill Creek project are being addressed in the Final EIS for that project currently being prepared by the DRBC.

Merrill Creek project

The DOI, under the heading, "Merrill Creek," states that the FWS recommended denial of a section 404 permit from the Department of the Army for the Merrill Creek project for various reasons.

Such a recommendation before completion of the Final EIS for this project appears premature. The DRBC is currently preparing the Final EIS for the Merrill Creek project, and the Army permit will not be issued before the EIS is completed.

The Merrill Creek project permit is not relevant to the Limerick operating license, as it has been shown to the satisfaction of the Federal courts that the Limerick project would be feasible without the Merrill Creek project.

Summary

The DRBC staff finds nothing in the DOI comments on the Limerick Generating Station EIS-OL that would justify denial of the operation licenses from the standpoint of water resources. Most of the concerns expressed by the DOI have been considered before in the court-approved environmental reviews of the Neshaminy Water Supply System and the Limerick station water supply by the DRBC. Other DOI concerns relate to the Merrill Creek Reservoir project, which is currently under environmental review by the DRBC and the U. S. Army Corps of Engineers.

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Appendix A

Delaware River Basin Commission
Resolution 83-13

A RESOLUTION to amend the Comprehensive Plan relating to criteria for defining drought warning and drought conditions, and to a schedule of phased reductions in diversions, releases and flow objectives during such periods.

WHEREAS, the allowable diversions out of the Delaware River Basin to New York City and northeastern New Jersey, as well as downstream releases from the City's upper basin reservoirs, are prescribed under the provisions of the 1954 amended decree of the United States Supreme Court; and

WHEREAS, the Commission has declared a drought emergency condition on two occasions in 1965 and 1981 pursuant to Section 3.3(a) and Section 10.4 of the Delaware River Basin Compact; and

WHEREAS, the adoption of criteria in advance as to what constitutes drought conditions warranting emergency action will be useful to water users and the general public, as well as to water management officials of the parties; and

WHEREAS, the experience during these emergencies has shown the value of a drought operation formula setting forth diversion rates and streamflow objectives for guidance of reservoir operation; and

WHEREAS, the Commission has held public hearings on May 25, June 2, and June 3, 1983 on the proposed criteria and schedule recommended by the parties to the amended 1954 decree of the United States Supreme Court, and has received and considered testimony from water users and other interested parties; now therefore, BE IT RESOLVED by the Delaware River Basin Commission:

1. The Comprehensive Plan and Article 2 of the Water Code of the Delaware River Basin are hereby amended by the addition of new Sections 2.5.3 and 2.5.4 to read as follows:

2.5.3 Schedule of Phased Reductions in Diversions, Releases and Flow Objectives During Drought

A. Criteria Defining Conditions

For purposes of water management pursuant to Section 3.3 and Article 10 of the Compact, diversions of water from the Delaware River Basin by the City of New York and State of New Jersey, compensating reservoir releases from the New York City Delaware Basin Reservoirs, reservoir releases from Beltzville Reservoir, Blue Marsh Reservoir, and other reservoirs under the jurisdiction or control of the Commission, and streamflow objectives at the USGS gaging stations located at Montague, New Jersey, and Trenton, New Jersey, shall be governed by a schedule based upon a differentiation among "normal", "drought warning", and "drought" conditions defined by the combined storage in the Cannonsville, Pepacton and Neversink Reservoirs as set forth in Figure 1 entitled "Operation Curves for Cannonsville, Pepacton and Neversink Reservoirs". The division of the drought-warning zone into upper and lower halves shall be defined as a physically equal division, or 20 billions of gallons in each zone.

B. Schedule of Reductions

The schedules of phased reductions set forth in Tables 1 and 2 shall govern (1) the maximum allowable rates of diversion of waters from the Delaware River Basin by the City of New York and State of New Jersey; (2) the minimum compensating releases to be made by the City of New York from its reservoirs in the upper Delaware Basin; and the streamflow

OPERATION CURVES FOR
CANNONSVILLE, PEPACTON AND NEVERSINK RESERVOIRS

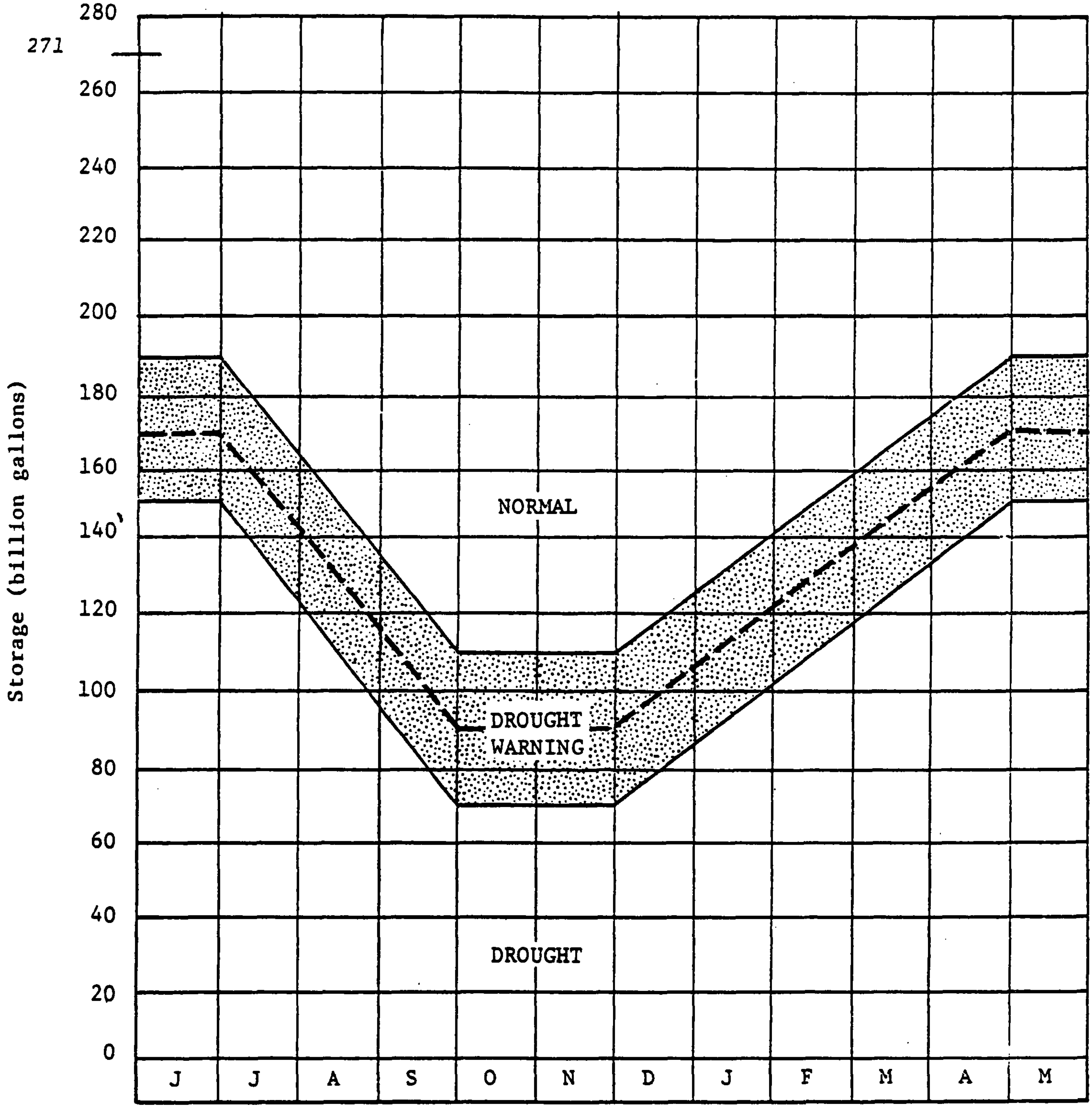

FIGURE 1

TABLE 1

Interstate Operation Formula for Reductions
In Diversions, Releases, and Flow Objectives
During Periods of Drought

NYC Storage Condition	NYC Div. mgd	NJ Div. mgd	Montague Flow Objective cfs	Trenton Flow Objective cfs
Normal	800	100	1750	3000
Upper Half— Drought Warning	680	85	1655	2700
Lower Half— Drought Warning	560	70	1550	2700
Drought	520	65	1100-1650*	2500-2900*
Severe Drought (to be negotiated based on conditions)				

*Varies with time of year and location of salt front as shown on Table 2.

TABLE 2

Flow Objectives for Salinity Control
During Drought Periods

Seven-day Average Location of "Salt Front," River-mile*	Flow Objective, Cubic Feet Per Second At:					
	Montague, N.J.			Trenton, N.J.		
	Dec-Apr	May-Aug	Sept-Nov	Dec-Apr	May-Aug	Sept-Nov
Upstream of R.M. 92.5	1600	1650	1650	2700	2900	2900
Between R.M. 87.0 and R.M. 92.5	1350	1600	1500	2700	2700	2700
Between R.M. 82.9 and R.M. 87.0	1350	1600	1500	2500	2500	2500
Downstream of R.M. 82.9	1100	1100	1100	2500	2500	2500

*Measured in statute miles along the navigation channel from the mouth of Delaware Bay.

objectives at the USGS gaging stations located at Montague, New Jersey and Trenton, New Jersey.

During "drought" conditions as defined by Figure 1, the streamflow objectives at the Montague and Trenton gaging stations shall be established as set forth in Table 2, in accordance with the seven-day average location of the 250 mg/l isochlor (the "salt front") in the Delaware Estuary.

C. Diversion Allowances and Release Requirements

(1) The City of New York may divert waters from the Delaware Basin at maximum rates equivalent to the quantities set forth in Table 1.

(2) The State of New Jersey may divert waters from the Delaware River Basin, from the Delaware River or its tributaries in New Jersey, at maximum rates equivalent to the quantities set forth in Table 1.

(3) The City of New York shall release water from one or more of its storage reservoirs in the upper Delaware Basin in quantities designed to maintain the minimum basic rates of flow at the USGS gaging station located at Montague, New Jersey, as set forth in Tables 1 and 2.

D. Computation of Diversions

(1) Diversions by the City of New York during "normal" conditions, as defined by Figure 1, shall be computed as provided in Section III.A.4. of the Amended Decree of the U. S. Supreme Court in New Jersey v. New York, 347 U.S. 995 (1954). At no time during a twelve-month period of the Water Year, commencing June 1, shall the aggregate total quantity diverted by the City of New York, divided by the number of days elapsed since the preceding May 31, exceed the maximum permitted rate of diversion.

(2) Diversions by the State of New Jersey during "normal" periods, as defined by Figure 1, shall be computed as provided in Section V.B. of the amended Decree of the U.S. Supreme Court in New Jersey v. New York, 347 U.S. 995 (1954). The total diversion by the State of New Jersey shall not exceed an average of 100 mgd as a monthly average, with the diversion on any day not to exceed 120 million gallons, and its total diversion without compensating releases shall not exceed 100 mgd during any calendar year.

(3) Diversions by the City of New York and State of New Jersey set forth in Table 1 during "drought warning" and "drought" conditions as defined by Figure 1, shall be computed as a daily running average, commencing on the day such drought warning or drought operations become effective, as provided in subsection E of this Section. If the allowable diversion for any condition period following entry into drought warning operations is not fully used, the unused portion may not be credited or used during subsequent periods.

(4) Upon return to normal condition operations, following a period of drought warning or drought operations, diversions by the City of New York and State of New Jersey shall be computed as averages commencing upon the date of return to normal operations.

E. <u>Effective Period for Drought Operating Schedule</u>

(1) The schedule of diversions, releases and streamflow objectives for "drought warning" operations as provided in Subsection B shall go into effect automatically whenever the combined storage in the New York City Delaware Basin Reservoirs declines below the drought

warning line, defined in Figure 1 and remains below that line for five consecutive days.

(2) The schedule of diversions, releases and streamflow objectives for "drought" operations as provided in Subsection B shall go into effect immediately whenever the combined storage in the New York City Delaware Basin reservoirs declines below the drought line defined in Figure 1, and remains below that line for five consecutive days.

(3) When the combined storage in the New York City Delaware Basin reservoirs (including the projected water runoff equivalent of actual snow and ice within the watersheds tributary to the reservoirs) reaches a level 15 billion gallons above the drought warning line, as defined in Figure 1, and remains above that level for five consecutive days, the drought warning and drought operations schedules set forth in Subsection B shall automatically terminate, and normal operations shall be resumed as provided in the Amended Decree of the U. S. Supreme Court in New Jersey v. New York, 347 U.S. 995 (1954).

(4) Pursuant to Section 3.3(a) of the Compact, the Parties to the U. S. Supreme Court Decree in New Jersey v. New York, 347 U.S. 995 (1954), have given their unanimous consent to adoption and implementation by the Commission of the drought operation schedules provided in this section. The Parties have agreed that the drought operation formula will go into effect automatically, and be binding on parties for not less than 180 days following the triggering of drought warning operations, unless terminated automatically by improved storage conditions as provided in Subsection E.3. During the 180-day period following triggering of drought warning operations, authorized representatives of the City of

New York, States of Delaware, New Jersey, and New York, and Commonwealth of Pennsylvania, as parties to the U. S. Supreme Court Decree, shall convene no less frequently than once each month to review current conditions, and they may extend, modify, or extend as modified the schedules provided in this section. If no unanimous agreement as to a continuing drought operation formula is reached within the 180-day period, all Parties shall be released from the terms of the formula and schedules and may pursue their rights and obligations under the Delaware River Basin Compact and the U. S. Supreme Court Decree.

2.5.4 Drought Emergency Actions

A. Criteria Defining Conditions

For purposes of water management pursuant to Section 3.3 and Article 10 of the Compact, the determination of drought warning and drought conditions shall be based upon the combined storage in the Cannonsville, Pepacton and Neversink Reservoirs, in accordance with Figure 1, entitled "Operation Curves for Cannonsville, Pepacton and Neversink Reservoirs". The division of the drought-warning zone into upper and lower halves shall be defined as a physically equal division, or 20 billions of gallons in each zone.

B. Drought Emergency Declaration

It is the policy of the Commission that a drought emergency will be declared for purposes of imposing mandatory in-basin conservation measures and other appropriate actions whenever combined storage in the New York City Delaware Basin reservoirs falls into the drought zone as defined in Figure 1 for five consecutive days. Termination of a drought emergency will be considered by the Commission whenever combined storage in the New York City Delaware Basin reservoirs reaches a level 40 billion gallons above the drought warning line as defined in Figure 1 and remains above that line for 30 consecutive days. The drought emergency will be terminated by the Commission whenever the combined storage in the New York City Delaware Basin reservoirs reaches 40 billion gallons above the drought warning line defined in Figure 1 and remains above that line for 60 consecutive days, unless the Commission unanimously agrees to extend the emergency.

Effect of Policy

This policy is not intended to extend, impair, or conflict with the Commission's authority under the Compact to declare or terminate a drought emergency or water-shortage emergency in the Basin, or subregion thereof, in other instances as conditions may require.

/s/ R. Timothy Weston
R. Timothy Weston, Chairman pro tem

/s/ Susan M. Weisman
Susan M. Weisman, Secretary

ADOPTED: June 29, 1983

NRC FORM 335 (7-77)

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

1. REPORT NUMBER *(Assigned by DDC)*
NUREG-0974

4. TITLE AND SUBTITLE *(Add Volume No., if appropriate)*
Final Environmental Statement related to the Operation of Limerick Generating Station, Units 1 and 2
Docket Nos. 50-352 and 50-353

2. *(Leave blank)*

3. RECIPIENT'S ACCESSION NO.

7. AUTHOR(S)

5. DATE REPORT COMPLETED

MONTH	YEAR
March	1984

9. PERFORMING ORGANIZATION NAME AND MAILING ADDRESS *(Include Zip Code)*
Division of Licensing
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

DATE REPORT ISSUED

MONTH	YEAR
April	1984

6. *(Leave blank)*

8. *(Leave blank)*

12. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS *(Include Zip Code)*
Same as 9 above.

10. PROJECT/TASK/WORK UNIT NO.

11. CONTRACT NO.

13. TYPE OF REPORT
Final Environmental Statement

PERIOD COVERED *(Inclusive dates)*

15. SUPPLEMENTARY NOTES
Pertains to Docket Nos. 50-352 and 50-353

14. *(Leave blank)*

16. ABSTRACT *(200 words or less)*

The information in this Final Environmental Statement is the second assessment of the environmental impact associated with the construction and operation of the Limerick Generating Station, Units 1 and 2. The first assessment was the Final Environmental Statement related to the construction of the facilities. The present assessment is the result of the NRC Staff review of the activities associated with the proposed operation of the station.

17. KEY WORDS AND DOCUMENT ANALYSIS

17a. DESCRIPTORS

17b. IDENTIFIERS/OPEN-ENDED TERMS

18. AVAILABILITY STATEMENT
Unlimited

19. SECURITY CLASS *(This report)*
Unclassfied

21. NO. OF PAGES

20. SECURITY CLASS *(This page)*
Unclassfied

22. PRICE
$

NRC FORM 335 (7-77)

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

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