NUREG-1064

Draft Environmental Statement
related to the operation of Millstone Nuclear Power Station, Unit No. 3

Docket No. 50-423

Northeast Nuclear Energy Company, et al

U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

July 1984

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ABSTRACT

This Draft Environmental Statement contains the second assessment of the environmental impact associated with the operation of Millstone Nuclear Power Station, Unit 3, pursuant to the National Environmental 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.

SUMMARY AND CONCLUSIONS

This Draft Environmental Statement, operating-license stage (DES-OL), was prepared by the U.S. Nuclear Regulatory Commission (NRC), Office of Nuclear Reactor Regulation (the staff).

1. This action is administrative.

2. The proposed action is the issuance of an operating license to Northeast Nuclear Energy Company (the applicant)* for the startup and operation of Millstone Nuclear Power Station, Unit 3 (NRC Docket No. 50-423), located in the Town of Waterford, New London County, Connecticut, on the north shore of Long Island Sound. The largest cities within 80 km (50 miles)** of the site are Hartford, New Haven, and Waterbury. Hartford, the capital of Connecticut, is located on the Connecticut River, approximately 64 km (40 mi) northwest of the Millstone site. New Haven is located approximately 62 km (38 mi) west of the site and Waterbury is located approximately 68 km (42 mi) west-northwest of the site. The unit will employ a four-loop pressurized water reactor (PWR) designed to produce up to 3579 megawatts thermal (MWt). A steam turbine-generator will use 3425 MWt of this heat to provide a net output of 1150 MW of electrical power. The exhaust steam from Millstone 3 will be condensed by a once-through flow of water from Niantic Bay that will be discharged through a quarry pond into Long Island Sound.

3. The information in this environmental statement represents the second assessment of the environmental impact associated with Millstone 3 pursuant

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*Northeast Nuclear Energy Company acts as agent and representative for the following owners: The Connecticut Light & Power Company; Western Massachusetts Electric Company; New England Power Company; The United Illuminating Company; Public Service Company of New Hampshire; Central Vermont Public Service Corporation; Mantaup Electric Company; City of Burlington, Vermont Electric Light Department; Chicopee Municipal Lighting Plant; Massachusetts Municipal Wholesale Electric Company; Vermont Electric Cooperative, Inc.; Vermont Electric Generation and Transmission Cooperative, Inc.; Central Maine Power Company; Village of Lyndonville Electric Department; Connecticut Municipal Electric Energy Cooperative; and Fitchburg Gas and Electric Light Company.

**Throughout the text of this document, values are generally presented in both metric and English units. (Exceptions are sometimes made in areas where the accepted standard in the discipline is expressed in 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.

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 an application in October 1972, to construct Unit 3, the staff carried out a review of the environmental impact that would occur during construction and operation. This evaluation was issued in February 1974 as a Final Environmental Statement - Construction Permit phase (FES-CP). After this environmental review, a safety review, an evaluation by the Advisory Committee on Reactor Safeguards, and public hearings, the U.S. Nuclear Regulatory Commission (NRC) issued Construction Permit No. CPPR-113 on August 9, 1974. The applicant has informed the NRC that as of June 25, 1984, the construction of Millstone 3 was about 86.5% complete.

The applicant has applied for a license to operate Unit 3 and submitted, by letter dated October 29, 1982, the required safety and environmental reports in support of the application. After the NRC conducted a predocketing and acceptance review and determined that sufficient information was available to start detailed environmental and safety reviews, the FSAR and Environmental Report (ER) were docketed on February 3, 1983.

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

   (a) Alteration of about 4.9 ha (12 acres) of additional land has been necessary to construct and operate Unit 3. This is not a significant detrimental environmental impact (Section 5.2.1).

   (b) Under the Federal Coastal Zone Management Act [16 USC 1453(2)] and the Coastal Zone Area Management Act [C.G.S.22a-93(14)(A)], existing tidal wetland on the Millstone site property is protected. This area, together with its immediate surroundings, is being managed as a wildlife area by the applicant (Section 5.2.1).

   (c) Land use along transmission lines is not expected to change as a result of station operation (Section 5.2.2).

   (d) Operation of the three units at the Millstone site will result in the creation of a plume of heated water covering up to about 180 ha (445 acres) at stack water following ebb tide with temperatures 2.2C° (4F°) or more above ambient water temperature or 500 ha (1235 acres) with temperatures 0.8C° (1.4F°) or more above ambient water temperature. This plume will be located in Twotree Island Channel (Section 5.3.1).

   (e) Chemical wastes discharged from Unit 3 to Long Island Sound will average about 231.6×10^3 kg/yr (255.3 tons/yr). About 165.6×10^3 kg/yr (182.8 tons/yr) will come from the makeup water demineralization system; about 2.7 kg/yr (3 tons/yr) from biocide additions to cooling water and about 63.0×10^3 kg/yr (69.4 tons/yr) from the condensate treatment system. Additionally, half of the total of about 7×10^3 kg/yr (7.7 tons/yr) of copper eroded from the station heat exchangers may be attributed to Unit 3. These releases will either be in very small amounts or be sufficiently diluted by cooling water flow that they will result in small incremental increases in concentration of chemical constituents in the station discharges. Adverse effects on biota of Long Island Sound are not expected as a result of these discharges (Sections 5.3.1 and 5.5.2).

(f) Operation of Millstone 3 will not have adverse effects on the regional water use from Niantic Bay and Long Island Sound, regional use of public water supplies, or domestic use of groundwater. The effect of the presence or operation of the plant on the 100-year floodplain will be negligible (Section 5.3.2).

(g) Periodic operation of the diesel generators and auxiliary boilers will not have an adverse effect on air quality (Section 5.4).

(h) Operation of Millstone 3 is not expected to have adverse impacts on terrestrial ecology (Section 5.5.1.1).

(i) The staff has found no evidence indicating that operation of the Millstone transmission system will have adverse effects on human health or on plant and animal life (Section 5.5.1.2).

(j) The staff has evaluated the biological conditions anticipated with operation of the Unit 3 intake and discharge into the quarry. Organisms in the vicinity of the intake structure will be subjected to impingement on the traveling screens, but impacts will be mitigated by return of impinged organisms via a sluiceway to Niantic Bay (Section 5.5.2).

(k) Entrainment effects will be minimized by design of the intake structure and the absence of chlorine in the circulating water system (Section 5.5.2).

(l) The intake entrainment and impingement levels with Millstone Units 1, 2, and 3 operating are projected to be approximately double the levels now estimated for Units 1 and 2. Localized impacts on the winter flounder population of Niantic Bay are expected due to entrainment losses; however, these impacts are judged to be small and negligible with respect to the winter flounder population of Long Island Sound. Mitigation of impingement via a fish return system for Units 1 and 3 should reduce the impingement mortality rate to about the existing level for Units 1 and 2 (Section 5.5.2).

(m) Operation of Millstone 3 will not have significant adverse impacts on any aquatic or terrestrial species identified as threatened or endangered on the Federal or State Lists (Section 5.6).

(n) The staff concludes that the operation and maintenance of Millstone 3 will have no significant impact on sites listed or eligible for listing in the National Register of Historic Places with the provision that the staff is waiting for a reply from the State Historic Preservation Officer concerning impacts associated with the transmission line corridor (Section 5.7).

(o) The staff concludes that the primary socioeconomic impacts of plant operation are tax benefits and employment. The staff does not expect the operating workers or their families to have any significant impact on public or private facilities (Section 5.8).

(p) The staff concludes that there will be no measurable radiological impact on any member of the public from routine operation of the Millstone 3 facility (Section 5.9.3.2).

(q) 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).

(r) 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 (i) the fact that considerable experience has been gained with the operation of similar facilities without significant degradation of the environment; (ii) the fact that, to obtain a license to operate, Millstone 3 must comply with the applicable Commission regulations and requirements; and (iii) a probabilistic assessment of the risk based upon the methodology developed in the reactor safety study (RSS), improvements in 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 Millstone 3 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 Millstone 3 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 Millstone site and environs that would warrant special consideration of alternatives for Millstone 3. (Section 5.9.4.6)

(s) The environmental impact of Millstone 3 as a result of the uranium fuel cycle is very small when compared with the impact of natural background radiation (Section 5.10).

(t) Based on the lack of significant sources of broadband noise on site and the very low level of availability of Unit 3 transformer tones off site, the staff concludes that no adverse community reaction would be expected from operation of Unit 3 (Section 5.12).

(u) Millstone 3 will provide approximately 5.6 billion kWh of baseload electrical energy annually (assuming that the unit will operate at an annual average capacity factor of 55%). The addition of the unit will add 1154 MW of capacity to the Northeast Nuclear Energy Company system (Section 6).

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. This Draft Environmental Statement is being made available to the public, to the Environmental Protection Agency, and to other agencies, as specified in Section 8.

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, after weighing the environmental, economic, technical, and other benefits against environmental and economic costs at the operating-license stage, the staff concludes that the action called for under NEPA and 10 CFR 51 is the issuance of an operating license for Millstone Nuclear Power Station, Unit 3, 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 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.

   (b) 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 license for Millstone 3. Monitoring of the aquatic environment shall be as specified in the National Pollutant Discharge Elimination System (NPDES) permit.

   (c) 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.

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FOREWORD

This Draft Environmental Statement-Operating License Stage (DES-OL) 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).

The NEPA states, among other things, that it is the continuing responsibility of the Federal government to use all practical means, consistent with other essential considerations of national policy, to improve and coordinate Federal plans, functions, programs, and resources to the end that the Nation may

- Fulfill the responsibilities of each generation as trustee of the environment for succeeding generations.
- Assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings.
- Attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences.
- Preserve important historic, cultural, and natural aspects of our national heritage and maintain, wherever possible, an environment that supports diversity and variety of individual choice.
- Achieve a balance between population and resource use that will permit high standards of living and a wide sharing of life's amenities.
- Enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

Further, with respect to major Federal actions significantly affecting the quality of the human environment, Section 102(2)(c) of the NEPA calls for the preparation of a statement on

- the environmental impact of the proposed action
- any adverse environmental effects that cannot be avoided should the proposal be implemented
- alternatives to the proposed action
- the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity

- any irreversible and irretrievable commitments of resources that would be involved in the proposed action should it be implemented.

An Environmental Report (ER-OL) accompanied the application for an operating license for this nuclear power station. In conducting the required NEPA review, the staff met with the applicant to discuss items of information in the ER-OL, to seek new information from the applicant that might be needed for an adequate assessment, and to ensure that the staff has a thorough understanding of the proposed project. In addition, the staff has obtained information from other sources that have assisted in this evaluation, and visited the project site and the surrounding vicinity. Members of the staff met with state and local officials who are charged with protecting state and local interests. On the basis of all the foregoing and other such activities or inquiries as were deemed useful and appropriate, the staff made an independent assessment of the considerations specified in Section 103(2)(c) of the NEPA and 10 CFR 51.

The evaluation led to the publication of this DES, which is being circulated to Federal, state, and local government agencies for comment. A notice of the availability of the ER-OL and the DES is being published in the Federal Register. Interested persons are also invited to comment on the proposed action and on the draft statement.

After receipt and consideration of these comments, the staff will prepare a Final Environmental Statement (FES), which will include a discussion of questions and concerns raised by the commenters and the disposition thereof. This FES also will contain conclusions as to whether--after the environmental, economic, technical, and other benefits are weighed against the environmental costs--the action called for, with respect to environmental values, is the issuance or denial of the proposed license, or its appropriate conditioning to protect environmental values. To facilitate review, the format used in the DES also will be used in the FES.

The information to be found in the various sections of this statement updates the environmental statement issued at the construction permit stage (FES-CP) in four ways: (1) by evaluating changes to facility design and operation that will result in different environmental effects of operation (including those that would enhance as well as degrade the environment) than those projected during the preconstruction review; (2) by reporting the results of relevant new information that has become available subsequent to the issuance of the construction permit stage environmental statement; (3) by factoring into the statement new environmental policies and statutes that have a bearing on the licensing action; and (4) by identifying unresolved environmental issues or surveillance needs that are to be resolved by means of license conditions.

Copies of this DES are available for inspection at the NRC Public Document Room, 1717 H Street, NW, Washington, DC 20555 and at the Local Public Document Room at the Waterford Public Library, Rope Ferry Road, Route 156, Waterford, Connecticut 06385. Single copies may be obtained, free of charge, by writing to the Division of Technical Information and Document Control, U.S. Nuclear Regulatory Commission, Washington, DC 20555.

Comments should be filed no later than 45 days after the date on which the Environmental Protection Agency notice of availability of this statement is published in the Federal Register.

Ms. Elizabeth L. Doolittle is the NRC project manager for Millstone Nuclear Power Station, Unit 3. Should there be any questions regarding the content of this statement, Ms. Doolittle may be contacted by telephone at (301) 492-7000 or by writing to

Ms. Elizabeth L. Doolittle
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1 INTRODUCTION

The proposed action is the issuance of an operating license (OL) to Northeast Nuclear Energy Company (NNECO) of Berlin, Connecticut,* for startup and operation of the Millstone Nuclear Power Station, Unit 3 (NRC Docket No. 50-423). Millstone 3 is located on a 200-ha (500-acre) site in the Town of Waterford, New London County, Connecticut, on the north shore of Long Island Sound. The Millstone site is also occupied by two operating nuclear power plant facilities. Millstone 1, a boiling water reactor (BWR), was licensed to operate in October 1970. Millstone 2, a pressurized water reactor (PWR), was licensed to operate in September 1975. Millstone 3 will use a four-loop PWR, with four steam generators, one steam turbine generator, a heat dissipation system, and associated auxiliary and engineered safeguards. Cooling water to condense the exhaust steam from the turbine generator will come from Niantic Bay. The cooling water will flow through the condenser and will be discharged through a quarry pond into Long Island Sound. This cooling method is also used for Units 1 and 2. Unit 3 is designed to operate with a maximum thermal output of 3579 MWt. The gross calculated output of the turbine generator is approximately 1209 MWe, with a net calculated electrical output of approximately 1156 MWe. The plant is being constructed for NNECO (the applicant), who will operate the plant.

1.1 Administrative History

On October 31, 1972, the Millstone Point Company and joint applicants filed an application with the Atomic Energy Commission, now Nuclear Regulatory Commission (NRC), for a permit to construct the Millstone Nuclear Power Station, Unit 3. Construction Permit No. CPPR-113 was issued on August 9, 1974, following reviews by the Nuclear Regulatory Commission's staff (the staff) and its Advisory Committee on Reactor Safeguards, as well as public hearings before an Atomic Safety and Licensing Board during the period from June 17, 1974 to July 25, 1974. The conclusions resulting from the staff's environmental review were issued as a final environmental statement for construction permit stage (FES-CP) in February 1975.

As of June 25, 1984, construction of Millstone Unit 3 was about 86.5% complete. NNECO estimates that Unit 3 will be ready for fuel loading in November 1985 and for commercial operation in May 1986.

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*Northeast Nuclear Energy Company acts as agent and representative for the following owners: The Connecticut Light & Power Company; Western Massachusetts Electric Company; New England Power Company; The United Illuminating Company; Public Service Company of New Hampshire; Central Vermont Public Service Corporation; Mantaup Electric Company; City of Burlington, Vermont Electric Light Department; Chicopee Municipal Lighting Plant; Massachusetts Municipal Wholesale Electric Company; Vermont Electric Cooperative, Inc.; Vermont Electric Generation and Transmission Cooperative, Inc.; Central Maine Power Company; Village of Lyndonville Electric Department; Connecticut Municipal Electric Energy Cooperative; and Fitchburg Gas and Electric Light Company.

On October 29, 1982, NNECO submitted an application including a Final Safety Analysis Report (FSAR) and Environmental Report (ER-OL) requesting issuance of an operating license for Millstone Nuclear Power Station, Unit 3. The FSAR and ER-OL were docketed on February 3, 1983, and the staff operational safety and environmental reviews were then initiated.

1.2 Permits and Licenses

The applicant has provided in ER-OL Section 12 a listing of the status of environmentally related permits, approvals, and licenses required from Federal and state agencies in connection with the proposed project. The staff has reviewed the listing and other information and is not aware of any potential non-NRC licensing difficulties that would significantly delay or preclude the proposed operation of the plant. Pursuant to Section 401 of the Clean Water Act of 1977, the issuance of a water quality certification, or waiver therefrom, by the Connecticut Department of Environmental Protection is a prerequisite to the issuance of an operating license by the NRC. This certification was granted on February 16, 1977 (ER-OL Table 12.0-1). The National Pollutant Discharge Elimination System (NPDES) permit, issued pursuant to Section 402 of the Clean Water Act, was granted by the Connecticut Department of Environmental Protection on December 30, 1974, and a modified NPDES permit was subsequently issued on November 8, 1983. The NPDES permit, as modified, is reproduced in Appendix G of this environmental statement.

2 PURPOSE OF AND NEED FOR ACTION

The Commission 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 51.53, 51.95, and 51.106(c)).

This policy has been determined by the Commission to be justified whether or not the additional capacity to be provided by the nuclear facility is needed to meet the applicant's load responsibility. The Commission has determined that the need for power is fully 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 CP. 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 OL. The Commission was further influenced by the substantial information that supports the conclusion that nuclear plants are lower in operating costs than conventional fossil plants. If conservation or other factors lower anticipated demand, utilities remove generating facilities from service according to their costs of operation, with the most expensive facilities removed first. Thus, a completed nuclear plant would serve to substitute for less economical generating capacity (47 FR 12940; 46 FR 39440, August 3, 1981).

Accordingly, this environmental statement does not consider "need for power." Section 6 does, however, consider the savings associated with the operation of the nuclear plant.

3 ALTERNATIVES

The Commission 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 ongoing and future OL proceedings 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 OL applicants in environmental reports to the NRC, nor by the staff in environmental impact statements prepared in connection with OL applications (10 CFR 51.53, 51.95, 51.106(c), and 51.106(d)).

In promulgating this amendment, the Commission noted that alternative energy source issues are resolved at the CP stage, and the CP is granted only after a finding that, on balance, no obviously superior alternative to the proposed nuclear facility exists. The Commission concluded that because of the economic advantage that operation of the nuclear plant would have over available alternative sources, this determination is unlikely to change even if an alternative is shown to be marginally environmentally superior in comparison to operation of the nuclear facility (47 FR 12940, 46 FR 39440).

By an earlier amendment (46 FR 28630, May 28, 1981), the Commission also provided that consideration of alternative sites will not be undertaken at the OL stage, except upon a showing of special circumstances under 10 CFR 2.758. Accordingly, this environmental statement does not consider alternative sites.

4 PROJECT DESCRIPTION AND AFFECTED ENVIRONMENT

4.1 Résumé

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

Minor changes in land use are described in Section 4.2.2. A detailed summary of water use that was not available when the FES-CP was issued is given in Section 4.2.3. Final designs for trash racks and traveling screens for the circulating water system are described in Section 4.2.4, which discusses other minor differences in the operation of that system. Section 4.2.6 presents the data on chemical addition to various plant systems, as shown in the ER-OL. Section 4.2.7 describes the route chosen for the 345-kV transmission line from Montville to Manchester, Connecticut. An updated hydrologic description--with more detailed information on coastal water, surface water, and groundwater--is given in Section 4.3.1. In Section 4.3.3, the results of water data collection since 1968 are given. Section 4.3.5 notes that surveys conducted since the FES-CP was issued have confirmed and quantified the description of terrestrial and aquatic resources in the FES-CP. Section 4.3.6 confirms that there is no anticipated impact on endangered and threatened species.

In Section 4.3.7, updated population figures for the area--both year round and transient--are discussed, and Section 4.3.8 discusses additional properties listed or eligible for listing in the National Register of Historic Places.

4.2 Facility Description

4.2.1 External Appearance and Plant Layout

These topics are discussed in FES-CP Sections 2.1, 2.7.2, and 3.1. The applicant reports that the external appearance remains unchanged from the CP stage descriptions (ER-OL Section 3.1). Figure 4.1 shows the location of the significant structures.

4.2.2 Land Use

A description of regional and site land use is in FES-CP Section 2.2 and ER-OL Section 2.1. Except as noted below, no changes have occurred in land use of the site and surrounding area since the FES-CP was issued (ER-OL Section 2.1.3). A 2-ha (5-acre) area on the site that was formerly set aside as a recreation area and information office is now used for construction laydown and placement of fill from the Unit 3 excavation (ER-OL Section 2.2.1.2). The office and recreation area are no longer planned. Also, the small portion of land on site formerly leased by the U.S. Navy is no longer used by the Navy (ER-OL Section 2.1).

The predominant land use within 10 km of the site is undeveloped agriculture. The other land uses still include residential, commercial, industrial, recreational, institutional, and transportation/communication (ER-OL Figure 2.1-24). The station property line encompasses approximately 200 ha (500 acres) and is identical with the site boundary and exclusion area boundary. The distance from the center of the Unit 3 containment structure to the nearest site boundary (minimum exclusion area) is 547 m (1794.7 feet) (ER-OL Section 2.1.1.3). Other major site measurements are shown in Figure 4.2 (ER-OL Figure 2.1-3).

The Millstone Nuclear Power Station is a national interest facility, as defined by the State of Connecticut's Coastal Management Program and as required by the Federal Coastal Zone Management Act. The operation of Millstone 3 will conform with the policies of municipalities and the State of Connecticut to protect facilities and resources that are in the national interest.

4.2.3 Water Use and Treatment

The volume of circulating water expected to pass through Millstone 3 (57 m^3/sec (2000 cfs)) has not changed since the issuance of the FES-CP. Table 4.1 and Figure 4.3 give a detailed summary of water use for Millstone 3 that was not available when the FES-CP was written. Under normal operating conditions, the total water use by the circulating and service water systems will be 59.4 m^3/sec (2097 cfs). Approximately 13,300 m^3/day (5.4 cfs) will be consumed for sanitary and potable use and for radioactive solid waste processing (ER-OL Section 3.3.2.3).

The circulating water system will draw water from the Niantic Bay area of Long Island Sound through the circulating and service water pumphouse. After passing through the condenser, the circulating water will be used to dilute the treated radioactive waste and small quantities of chemical wastes (ER-OL Section 4.2.6). The circulating water will be heated approximately 9.4C° (17F°) above the inlet temperature before it is discharged to the quarry at the southeast end of the Millstone site. The heated effluent from Unit 3 will be combined with that of Units 1 and 2 before it is discharged into Long Island Sound (ER-OL Section 4.2.4). The combined effluent from the three units will increase the temperature of the discharge from the quarry by approximately 11.9C° (21.5F°) above ambient (ER-OL Section 5.1.2.6). This is an increase of approximately 0.6C° (1F°) above that projected in the FES-CP (Section 3.3.1).

Service water will be used as a coolant for various heat exchangers. It will not contact radioactive material or components (Section 4.2.4). Water for the service water system is withdrawn from separate intake bays between the traveling screens and the circulating water pumps. Strainers within the service water pumps are self cleaning; debris removed from the strainers is discharged to Niantic Bay. The service water will be mixed with the circulating water and discharged to the quarry and, ultimately, into Long Island Sound (ER-OL Section 3.4.2).

A chlorination system is designed into the service water system to prevent biofouling. Dilution water for the chlorination system is provided directly from the service water system upstream of the chlorine injection nozzles. The rate of chlorine addition is monitored by a residual chlorine analyzer to ensure that the free available chlorine concentration at the confluence within the circulating water discharge tunnel is less than 0.1 ppm. The chlorination system is operated once every 8 hours, with each of the two service water flow paths alternately chlorinated once for 30 minutes. This cycle continues while the unit is in operation (ER-OL Section 3.4.2).

4.2.4 Cooling System

4.2.4.1 Circulating Water System

The Millstone 3 once-through circulating water system (Figure 4.4) pumps salt water from Niantic Bay of Long Island Sound through a single-pass, triple-shell condenser at a rate of approximately 57 m^3/sec (2000 cfs). This circulating water will condense the steam rejected by the main turbine. The temperature range of water entering the pumphouse is expected to be between 0.6°C (33°F) and 24°C (75°F). The temperature rise of the water circulating through the condenser is expected to be 9.4C° (17F°) above that of the inlet temperature. The circulating water discharged from Unit 3 will mix in the quarry with that discharged from Units 1 and 2. The combined flow from the three units will be approximately 118 m^3/sec (4160 cfs), with a calculated maximum temperature rise at full load of 11.7C° (21F°) (ER-OL Section 3.4.1).

The circulating and service water pumphouse is divided into six bays that supply water to six circulating water pumps, four service water pumps, and two screenwash pumps. During normal operation, the average water velocity within each bay is approximately 0.24 m/s (0.8 fps) at the lowest water elevation (ER-OL Section 3.4.1). Each bay contains a trash rack and a traveling screen. Since the FES-CP was prepared, the designs for the trash rack and traveling screen have been finalized. A summary description of these structures follows.

The trash racks are 4.9 m (16 feet) wide and have 1.3-cm (0.5-inch)-thick by 8.9-cm (3.5-inch)-deep vertical steel bars installed 6.4 cm (2.5 inches) apart on centers at a slope of 5 to 1. Two traversing trash rakes operated by motorized cable hoists mounted on a steel superstructure remove debris from the trash racks and deposit it in trash carts for removal. The material in the trash carts is disposed of on site in approved locations.

The traveling screens consist of a continuous band of screen panels 4.3 m (14 feet) wide by 0.61 m (2 feet) high. The panels are constructed of 4.8-mm (0.19-inch) mesh copper cloth that has a ± 60% clear opening. The screens automatically operate in response to the differential water level across each screen. Water is sprayed from the screen wash headers at 585 P_a (85 psi) to clean debris from the screens into an upper trash trough, and at 69 P_a (10 psi) to flush organisms from the fish trays that are attached to the lower edge of each traveling screen panel, or from the traveling screen panels, into a fish trough (ER-OL Section 3.4.1). The debris is removed from the trash trough by a motorized conveyer. The fish in the trough are transported by water through a fish sluiceway from the pumphouse back into Niantic Bay on the west side of the pumphouse. The approximate location of the fish return to Niantic Bay is indicated by an asterisk (*) on Figure 4.4.

After passing through the intake bays, the circulating water flows from the six circulating water pumps to the condenser through six independent 183-m (600-foot)-long, 213-cm (84-inch)-diameter pipelines. Approximately 114 m^3/min (30,000 gpm) from the service water system enters the discharge system down-stream of the confluence of the discharge pipelines. The combined flow goes to the quarry through a 503-m (1,650-foot)-long tunnel that discharges from a seal pit over a weir and into the quarry. The water discharges to the quarry from the seal pit structure at an average velocity of approximately 0.76 m/sec (2.5 fps) (ER-OL Section 3.4.1).

The three groups of paired circulating water pumps supplying each condenser shell are interconnected at the circulating and service water pumphouse by lateral passageways and at the condenser inlet and outlet water boxes by cross-connecting 168-cm (66-inch)-diameter motor-operated valves. These cross connections provide for recirculation of the discharged water for backflushing and thermal treatment of the condenser and the intake lines and the pumphouse. An Amertap tube cleaning system that injects sponge rubber balls into the condenser cooling tubes is provided for each condenser flow path to maintain clean tubes and to eliminate the need for a chlorine injection system in the circulating water system. However, the applicant has made provisions in the design of the service water chlorination system to retrofit a chlorine injection system for the circulating water system if thermal backwashing or mechanical cleaning prove unsuccessful (ER-OL Section 3.4.2). If chlorination becomes necessary, intermittent sequential chlorination (as regulated by the NPDES permit) would occur downstream of the traveling screens in each circulating water intake bay as an additional measure for slime control. If additional control of fouling mollusks is required, continuous chlorination equipment will be installed. Presently the applicant plans to control mollusk growth within the intake structure by use of a thermal backwash system. Although the frequency, duration, and maximum temperature of thermal backwashing have not yet been determined for Millstone 3, a study has been conducted at Unit 1 for mussel control. Study results to date indicate that biofouling is successfully controlled with six 20-minute treatments a year for each intake bay, at a temperature of 40°C (105°F) (Johnson, Foertch, Keser, and Johnson, 1983).

Under normal conditions, all six circulating water pumps operate in parallel through all six condenser flow paths to provide required heat removal. During this period, all inlet and outlet cross-connecting valves are fully closed, and all pump discharge and condenser discharge valves are fully open. Under these conditions the pumps each supply a flow of approximately 580 m^3/min (152,000 gpm) at a head of 8.4 m (27 feet). The total flow of 3480 m^3/min (912,000 gpm) receives heat at a rate of 7.9×10^{12} J/hr (7.5×10^9 Btu/hr) resulting in a design temperature rise of 9.4C° (17F°) above the intake temperature. This is 0.6C° (1F°) less than that reported in the FES-CP (Section 3.3.2). Under normal conditions, the travel time of the circulating water through the condenser is approximately 7 seconds. The total time of travel for the circulating water through the intake, piping, condenser and discharge tunnel is approximately 4.5 minutes. The total time of travel of the discharged water through the quarry to Long Island Sound is approximately 30 minutes.

4.2.4.2 Service Water System

The service water system provides cooling water for heat removal from the reactor auxiliary systems during all modes of operation and from the turbine auxiliary systems during normal operation. This system also supplies lubrication water for the service and circulating water pump bearings. The service water system consists of two redundant flow paths, each with two pumps and associated pipes, heat exchangers, and valves. The service water pumps are located in separate intake bays between the traveling screen and the circulating water pump. Each pump supplies 50% of the required flow at a rate of 57 m^3/min (15,000 gpm) and a total dynamic head of 36.6 m (120 feet) (ER-OL Section 3.4.2).

The service water system draws water from Niantic Bay through the circulating and service water pumphouse, at a rate of 1.9 m^3/s (70 cfs), pumps it through the various heat exchangers, and then discharges it via the circulating water tunnel to the quarry. Service water flow and heat load requirements under all operating conditions are listed in Table 4.2. The service water discharge flow constitutes 1/30th of the circulating water flow.

4.2.5 Radioactive Waste Treatment

10 CFR 50.34a requires an OL applicant to provide a description of the design of equipment to be installed for keeping levels of radioactive materials in effluents to unrestricted areas as low as reasonably achievable (ALARA), taking into account the state of technology and the economics of improvement (1) in relation to benefits to the public health and safety and other societal and socioeconomic considerations and (2) in relation to the utilization of atomic energy in the public interest. Appendix I to 10 CFR 50 provides numerical guidance on design objectives for light-water-cooled nuclear power reactors to meet the ALARA requirements.

To meet the requirements of 10 CFR 50.34a, the applicant has provided final designs of radwaste systems and effluent control measures for keeping levels of radioactive materials in effluents to unrestricted areas within the design objectives of Appendix I to 10 CFR 50. The applicant has performed a cost-benefit analysis, as required by Section II.D of Appendix I to 10 CFR 50. In addition, the applicant has 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 operation, including anticipated operational occurrences.

The staff's detailed evaluation of the liquid and gaseous radwaste systems and the capability of these systems to meet the requirements of Appendix I will be in Chapter 11 of the Millstone 3 safety evaluation report (SER). The quantities of radioactive material calculated by the staff to be released from the plant are presented in Section 5.9 of this environmental statement, along with the calculated doses to individuals and to the population that will result from these effluent quantities. The staff's evaluation concludes that the final designs of radwaste systems and effluent control measures are capable of meeting the design objectives of Sections II.A, II.B, and II.C of Appendix I to 10 CFR 50, so that radioactive materials in effluents released to unrestricted areas can be kept ALARA. The staff also concludes that there are no cost-effective design augmentations to reduce the cumulative population dose at a favorable cost-benefit ratio, and that the final design of gaseous and liquid radwaste systems meets the requirements of Section II.D of Appendix I to 10 CFR 50.

When an OL is issued, the applicant will be required to submit Technical Specifications that will establish release rates for radioactive material in liquid and gaseous effluents. These specifications will also provide for the routine monitoring and measurement of all principal release points to ensure that the facility operation conforms with Appendix I to 10 CFR 50.

4.2.6 Nonradioactive Waste Management Systems

Information on chemical addition to the various systems is shown in Table 4.3. A brief summary of the chemical and biocide systems and waste products will be presented in this section.

Makeup Water Treatment System

The makeup demineralizer system for Unit 3 consists of two trains, each with a capacity of 470 L/min (124 gpm). Under normal operating conditions, chemical regeneration of one of the two trains is required once a week. The total regeneration waste volume per train is approximately 121,000 L (32,000 gallons). The main constituent of this waste is sodium sulfate as a byproduct of the sulfuric acid and sodium hydroxide used as regenerating chemicals.

Regeneration wastes from one train and the mixed-bed demineralizer resins contain approximately 3230 mg/L of sulfate and 1460 mg/L of sodium. Regeneration wastes from the cation, anion, and mixed-bed demineralizers are neutralized to a pH between 6.0 and 9.0 standard units and discharged to the circulating water systems tunnel at a rate of less than 1% of the circulating water flow. The neutralization system is a batch process in which the wastes are recirculated within the waste regenerant neutralizing sump and sulfuric acid or sodium hydroxide is added until the pH reaches a value between 6.0 and 9.0.

Condensate Polishing Demineralizer System

Eight mixed-bed demineralizers (seven operating and one spare), each with a capacity of 10,690 L/min (2820 gpm), maintain water quality for the condensate and feedwater system. Under normal operating conditions, one polisher (demineralizer) per day will be regenerated using sulfuric acid and sodium hydroxide. The total volume of regeneration waste per polisher is approximately 121,000 L (32,000 gallons), of which 87,100 L (23,000 gallons) are discharged to the chemical waste sump to be neutralized and monitored for radioactivity. The remaining 34,100 L (9000 gallons) are recycled to the water recovery tank.

If the regeneration wastes discharged to the chemical waste sump are determined to be radioactive, they are transferred to the condensate demineralizer liquid waste system for treatment (FES-CP Section 3.4.1 and ER-OL Section 3.5.2). Otherwise, the regeneration wastes are neutralized, in a way similar to that used for the makeup demineralizer system, to a pH of 6.0 to 9.0, and they are discharged at a rate of less than 1% of the total flow rate to the circulating water discharge tunnel. The main constituent of the waste is sodium sulfate that results from use of the acidic and caustic chemicals for regeneration (FES-CP Table 3.4 and ER-OL Tables 3.6-1 and 4.2-6).

Biocide Wastes

As described above, the circulating water system uses three pairs of pumps for the three condenser shells. Interconnection of each pair of pumps allows recirculation of the discharged water for backflushing of the condenser and for biofouling control of the intake lines and pumphouse. A mechanical condenser tube cleaning system (Amertap), employing sponge rubber balls, will control biofouling in the condenser. Chlorination of the circulating water for biofouling control is not anticipated.

The service water system is a once-through cooling system that provides cooling water to the engineered safety features building, control building, auxiliary building, turbine building, and other unit structures. The service water system is treated by injection of a gaseous chlorine solution to control biofouling. This chlorination occurs three times a day for 30-minute periods, for a total of 1.5 hours per day. The chlorination rate is monitored by periodic grab sample analysis (NPDES Permit, Appendix G) to ensure that the concentration of free available oxidant is maintained at 0.1 ppm or less at the point where the mixture of service water and circulating water is discharged to the quarry (applicant's response to staff question (RQ) 291.9). The free residual oxidant in the service water system is reduced after it is mixed with the circulating water by the oxidant demand of that system. Approximately 3700 kg/yr (8200 lb/yr) of chlorine (as Cl_2) for service water chlorination will be discharged to the quarry by the Unit 3 system. The NPDES permit restricts the amount of chlorine to be used by the Unit 3 system to a daily maximum of 1386 kg/day (3000 lb/day) and the daily maximum free residual oxidant concentration is limited to 0.25 mg/L. The concentration of free available oxidant will be reduced from 0.1 mg/L at the point of discharge to less than 0.05 mg/L (detection limit) after mixing with water in the quarry.

Floor and Equipment Drainage

Nonradioactive floor and equipment drainage from pump seal leaks, pump seal and bearing water, floor washing, and other related draining will be discharged through the yard storm sewer to Niantic Bay. Oil-contaminated floor drainage is conveyed to oil/water separators before discharge. The oil that is removed is collected in drums and hauled offsite for disposal or recycling. The volume of drainage discharged to the yard storm drain varies on a daily basis; however, there are three oil/water separators with a design capacity of 380 L/m (100 gpm) to handle drainage from Unit 3 (ER-OL Section 3.6). Oil and grease concentrations in the effluent discharged to the yard storm drain are limited by terms of the NPDES permit to an average daily concentration of 10 mg/L and a maximum of 20 mg/L.

Steam Generator Blowdown

The steam generator blowdown system provides a means of controlling the suspended solids concentration and the chemical concentration of the steam generator shell water. The maximum blowdown rate for each of the four steam generators is 340 L/min (90 gpm). Blowdown from each steam generator is conveyed to the blowdown flash tank where the temperature is maintained slightly above the normal operating temperature for the feedwater heater shells. Steam from the flash tank is conveyed to the feedwater heaters. Because of the difference in pressure, the liquid in the flash tank drains to the condensate side of the condenser. Contaminants are removed from the liquid to the chemical waste sump by the condensate polishing demineralizers.

Waste Test Tank Discharges

Distillate from the waste evaporators is transported to the waste test tank and, after demineralization, is discharged to the primary grade water storage or to the circulating water discharge tunnel, depending upon the plant water balance. The waste evaporators for Unit 3 are designed for the assumption that all distillate will be discharged to the circulating water. The waste evaporator will process approximately 20.3x10^6 L/yr (5.3x10^6 gal/yr) of liquids from the condensate demineralizer (18.2x10^6 L/yr (4.8x10^6 gal/yr)) and the reactor plant aerated drains (2.2x10^6 L/yr (5.7x10^5 gal/yr)) (ER-OL Section 3.6.4.3).

Corrosion Inhibitors

Hydrazine will be used in the Unit 3 closed-loop reactor coolant system to remove trace quantities of dissolved oxygen. Very small quantities of hydrazine may leak into the circulating water. Hydrazine reacts chemically with oxygen to form water and nitrogen, and at high temperatures it decomposes to form ammonia and nitrogen.

Hydrazine is also used in the component cooling system as a corrosion inhibitor. Leakage from this system will be treated by the waste evaporator so that there will be no discharge to the circulating water system.

Sanitary Wastes

With a normal operating population of approximately 400 people, the discharge to the septic tank system associated with operation of Unit 3 is estimated to be 30,280 L/day (8000 gpd). This waste will be conveyed to a two-compartment 57,000-L (15,000-gallon) septic tank that serves the Millstone Nuclear Power Station.

Trash Rack Effluents

Debris entering the intake structure will be trapped on the trash racks. This debris will be removed by a trash rake and deposited in trash carts (see Section 4.2.4 above). Debris in the trash carts will be removed periodically and disposed on the site.

As discussed above, the design of the traveling screens has been changed since the FES-CP was issued. The new design includes fish trays along the lower edge of the screen panels. Fish are washed from the screens and fish trays with a gentle spray (69 P_a (10 psi)) into the fish trough. The fish trough discharges into a 30-cm (12-inch)-diameter fiberglass pipe that carries the fish from the trough and returns them to Niantic Bay. The location of the point of return is in a small cove area on the west side of the pumphouse.

4.2.7 Power Transmission System

As noted in the FES-CP, the only new line required for Unit 3 is a 345-kV circuit from the Millstone switchyard to the Manchester substation, a distance of about 75 km (47 miles). For the portion of this line between U.S. route I-95 in Waterford and Hunts Brook Junction in Montville, Connecticut, the applicant considerd two alternatives, both about 7.8 km (4.9 miles) long (FES-CP Figure 3.8). After the FES-CP was issued, the applicant chose alternative II, which uses the existing right-of-way north from Waterford to Montville. The final route is shown on Figure 4.5 (ER-OL Figure 3.9-2). The new circuit will be added on new arms on existing 345-kV structures or carried on new H-frames built to one side of existing 345-kV towers. The land use, frontage, and road crossings for the line remain as summarized in FES-CP Table 3.7.

Briefly, the line crosses about 78% undeveloped land, 12% agricultural land, 3% residential land, and 7% other developed land. Constructing the line entailed clearing about 142 ha (350 acres). The route avoids all Federal lands and does not cross existing or proposed Federal Wild and Scenic Rivers in the area.

4.3 Project-Related Environmental Description

4.3.1 Hydrology

The hydrologic description is in FES-CP Section 2.5. The hydrologic description below has been updated to reflect new information gathered since the FES-CP was prepared. It also includes a more detailed description of the coastal water, surface water, and groundwater at and adjacent to the plant site.

4.3.1.1 Coastal Waters

As noted above, Millstone Unit 3 shares the site on the tip of Millstone Point with Units 1 and 2. The site is between Niantic Bay on the west and Jordan Cove on the east. Both of these embayments adjoin Long Island Sound. Normal astronomical tides at Millstone Point are semidiurnal, with the mean range of 0.83 m (2.7 feet) and a spring range of 1 m (3.2 feet). The mean period of the tide is 12 hours-25 minutes. Observed water levels in excess of mean high water occur, on an average, as follows: in excess of 0.9 m (3 feet), about once a year; in excess of 0.6 m (2 feet), about 5 times a year; and in excess of 0.3 m (1 foot), about 98 times a year. Extreme variations in the water levels are storm induced and result from tropical windstorms (hurricanes) and extra-tropical windstorms. During the past 45 years, four hurricanes have given rise to abnormally high stillwater levels ranging from 1.8 m (6.0 feet) to 3.0 m (9.7 feet) above mean sea level (msl), not including waves. The extreme water levels recorded in the vicinity of Millstone Point during these hurricanes are as follows:

Hurricane date	Maximum water level above msl
September 21, 1938	3.0 m (9.7 feet)
September 14, 1944	1.9 m (6.3 feet)
August 31, 1954	2.7 m (8.9 feet)
September 12, 1960	1.8 m (6.0 feet)

The probable maximum hurricane (PMH) surge stillwater level is 6.0 m (19.7 feet) msl. The design-basis flood (maximum combination of storm surge and wave runup associated with the PMH) established for Millstone 3 is 7.25 m (23.8 feet) msl. Cooling water for the Millstone 3 once-through cooling system comes from Niantic Bay through an intake structure on the shoreline and is returned into an abandoned quarry that is connected to Long Island Sound.

Tidal current in Long Island Sound adjacent to the site has peak flood tide velocity of 0.53 m/sec (1.75 fps) and peak ebb tide velocity of 0.45 m/sec (1.48 fps).

The average salinity in Long Island Sound adjacent to the site is 28 to 30 parts per thousand (ppt). This is slightly less than that of the open sea (35 ppt). The salinity values observed adjacent to the site ranged from 31 to 32 ppt for the maximum and 26 to 28 ppt for the minimum.

Surface water temperatures have been monitored at Millstone Point and vicinity since 1966. The water temperature at the intake structure generally varies from a low of 0.6°C (31°F) in January and February to a high of 25.5°C (78°F) in August and September.

Temperature and salinity data were obtained in a number of locations in the nearby Twotree Island Channel and the entrance to Niantic Bay. The data were taken at high and low tides at various depth intervals. The constancy of the temperature and salinity with depth indicates that the Long Island Sound in the vicinity of Millstone Point is very thoroughly mixed by mechanical turbulence. There is a 0.3C° (0.5F°) temperature difference near the surface of the low tide measurements at several locations; these differences probably are caused by solar heating. There is no significant horizontal variation in temperature and salinity.

4.3.1.2 Surface Water

There are no major rivers or streams in the vicinity of Millstone Point, nor are there any water courses on the site. A number of small brooks flow into the Niantic River and then into Niantic Bay northwest of the site. Any flooding of these brooks would not directly affect the site or significantly raise the water levels in Niantic Bay, Jordan Cove, or Long Island Sound in the vicinity of the site. All site drainage, including the roofs of safety-related buildings, will be designed on the basis of the probable maximum precipitation to ensure against the local flooding of station facilities.

Bedrock is exposed at the south end of the site, but it is covered with a dense glacial till on the higher ground to the north. Because both the bedrock and the glacial till are quite impervious, precipitation does not permeate into it readily, and most of the precipitation runs off the surface directly into Niantic Bay or Jordan Cove. Some surface water collects in surface depressions in the northern part of the site.

4.3.1.3 Groundwater

The water table aquifer in the plant area lies in the overburden, which consists of varying thicknesses of both ablation and basal tills, with occasional permeable lenses of sand. Below these tills is a hard crystalline bedrock with tight, moderately spaced joints. In the area of the emergency generator enclosure and the control building, the surface of the basal till is about 4 m (13 feet) (2.7 m below plant grade) while the bedrock is about -2.1 m (-7 feet) (10 m below plant grade). In the area of the intake structure, bedrock is at about -12.2 m (-40 feet) msl. Both the basal till and overlying ablation till are relatively impervious, with the ablation tills more pervious than the basal tills. Very little water was observed entering the excavations through the bedrock, indicating that the permeability of the bedrock is very low and that very little groundwater or seawater seeps through the site bedrock.

The prevalence of bedrock outcrops at higher elevations (approximately 2440 m (8000 feet) north and 1070 m (3500 feet)) northeast of the site indicates that the bedrock acts as a groundwater and surface water divide, isolating the overburden adjacent to the plant from soils further inland. The groundwater level is subject to considerable seasonal fluctuations. The recharging of the groundwater would primarily be from infiltration of local precipitation, with probable migration to the adjacent waters of Long Island Sound. The groundwater surface has a gradient generally sloping from northeast to southwest. Essentially all of the groundwater movement is restricted to the soil overburden. Observation of the groundwater near the shoreline showed tidal fluctuations, suggesting that the occasional sand lenses can be quite permeable. Accidental contamination of the groundwater would, therefore, flow away from any groundwater users. The potential effects of radioactivity accidentally released to the groundwater are discussed in the SER.

4.3.2 Water Use

The coastal waters adjacent to the station site are used mainly for recreation such as water sports, fishing, and boating, although further offshore the deeper waters of Long Island Sound are used for commercial fishing and shipping. Unit 3 will use about 57.5 m^3/sec (2032 cfs) of seawater in its once-through condenser cooling system, but an inexhaustible supply of seawater is available. The impact of the water use is discussed in Section 5.3.

Virtually all the potable water used in the area is groundwater. The Town of Waterford, which uses groundwater sources, supplies all of the fresh water for operation of Millstone 3.

There are three shallow wells on the station site, all of which are up gradient from the containment structure. None of these onsite wells provides domestic drinking water or water for the station operation. One of these wells is about 2.0 km (6600 feet) to the north-northeast and is connected to the second well by a 4-inch pipeline. The second well is about 1.2 km (4000 feet) to the northeast and is used in conjunction with well No. 1 to supply drinking water (seasonally) to a baseball field. Both of these wells can pump water at the rate of 227 L/min (60 gpm). The third well is about 0.55 km (1800 feet) to the northwest and has been abandoned.

4.3.3 Water Quality

Since 1968 water quality data have been collected in the vicinity of the Millstone site where operation of the plant would be expected to have an effect on water quality. The sampling locations are shown in Figure 4.6. Average concentrations of water quality parameters as analyzed quarterly and monthly are summarized in Tables 4.4 and 4.5, respectively.

Sampling data presented by the applicant show that the alkalinity levels in Long Island Sound (230 mg/L) are higher than those reported for the open ocean (120 mg/L) (Martin, 1970). Calcium concentrations (245 mg/L) were approximately half the value reported for the open ocean; values of potassium (500 to

650 mg/L) were nearly twice that reported for the open ocean (380 mg/L). Levels of magnesium fluctuated from a high of 1800 mg/L in June to a low of 775 mg/L during spring runoff.

Levels of nitrogen are generally low in Long Island Sound. Phosphate concentrations reach a maximum after fall turnover and decrease gradually to a minimum in April (ER-OL Section 2.4). Baseline data for monthly concentrations of selected trace metals are shown in Table 4.5. The pH values recorded in the vicinity of Millstone range from 7.5 to 7.7 standard units; values greater than 8.0 standard units were recorded on the flood tide in March, October, November, and July. Values of 8.1 to 8.3 standard units are reported from the open ocean. Levels in Long Island Sound may be lower as the result of freshwater input from the Thames and Connecticut Rivers.

4.3.4 Meteorology

The meteorology and climatology information in FES-CP Section 2.6 is still valid. However, the extreme temperature and precipitation values given in FES-CP Table 2.4 have changed as a result of several additional years of observations at the Bridgeport National Weather Service Office since 1971.

Temperature extremes measured through 1981 were as low as -20°F (-29°C) and as high as 103°F (39.4°C). The maximum 24-hour precipitation measured was 175 mm (6.89 inches).

4.3.5 Terrestrial and Aquatic Resources

4.3.5.1 Terrestrial Resources

Terrestrial biota of the Millstone site are described in FES-CP Section 2.7.2. Since the FES-CP was issued, the applicant has completed a 1973-74 site survey and a 1977 follow-up reconnaissance survey. For the most part, these surveys confirmed and quantified the description in the FES-CP; they are reported in ER-OL Section 2.2.1. Briefly, the approximate 75% of the site not occupied by structures and construction support facilities presents a mosaic of vegetative communities in various stages of succession. The most common communities are old field, mesic, xeric, and riparian hardwood forest; and coastal marsh and beach. About 2 ha (5 acres) on the site is occupied by an abandoned nursery. Habitats on the site support a variety of animal species, mostly species common in the region. The site, particularly the marsh and associated woods and pond, provides habitat for waterfowl and wading birds such as grebes and herons. The applicant maintains three nesting platforms for osprey; two of these have been used each year since their construction.

4.3.5.2 Aquatic Resources

The FES-CP describes the aquatic resources in the vicinity of the Millstone station. ER-OL Section 2.2.2 provides additional information obtained as the result of continued baseline and operational sampling for Units 1 and 2. Information on ecological sampling locations is in Figure 4.6. Sampling sites were selected to be representative of both areas that could be affected by plant operation and those outside the influence of the plant. A summary of information obtained since the FES-CP was issued follows.

Approximately 120 taxa of phytoplankton were collected in the vicinity of the Millstone Units 1 and 2 discharge from 1977 through 1980. Ten taxa constituted more than 90% of the total. *Skeletonema costatum* and unidentified microflagellates were consistently most abundant in each of the sampling years. Diatom blooms occurred in the spring; microflagellates and dinoflagellates dominated during the summer; diatom blooms of lesser magnitude occurred in the fall. Spring and summer blooms of phytoplankton had densities averaging up to 11×10^6 cells/liter.

Copepods were the predominant zooplankton in the site vicinity. There are two major seasonal communities, winter-spring and the summer-fall, both dominated by copepods. In addition, large numbers of crab larvae occur during the summer and fall. Although the abundance of individual zooplankton species differs from year to year, the overall community appears to remain relatively stable.

Of the 60 taxa of ichthyoplankton collected, there are six dominant taxa: anchovies (*Anchoa* spp.), sand lance (*Ammodytes* spp.), winter flounder (*Pseudopleuronectes americanus*), sculpins (*Myoxocephalus*), cunner (*Tautogolabrus adspersus*), and tautog (*Tautoga onitis*). These account for more than 90% of the fish eggs and larvae collected.

The predominant fish eggs collected during the winter were Atlantic cod (*Gadus morhua*), Atlantic tomcod (*Microgadus tomcod*), and winter flounder. Fish egg density reaches a maximum in June ($29.6\ \mathrm{m}^3$) after spawning of labrids (cunner and tautog), and maximum larval density occurs in July ($3.7/\mathrm{m}^3$) (ER-OL Section 2.2.2.3). Cunner eggs are the most abundant egg collected annually. Winter flounder are the dominant larvae collected during the spring (April-June). Anchovies account for both high larval and egg numbers in July. Atlantic menhaden (*Brevoortia tyrannus*) are the most abundant larvae and eggs in the fall (October-December) (ER-OL Section 2.2.2.3).

Differences in annual, seasonal, and spatial densities of ichthyoplankton can result from changes in wind speed, water currents, water temperature, adult migration and spawning habits, and larval behavior. Larval anchovies, cunner, tautog, and sand lance were collected in greater densities in mid-Niantic Bay than in the vicinity of the discharge. The density of winter flounder eggs and small larvae found in the Niantic River is higher than the density found near the discharge; the Niantic River is a primary spawning area for winter flounder (ER-OL Section 2.2.2.3).

Mussels, barnacles, wood-boring arthropods, and shipworms are the primary fouling organisms found in the plant vicinity. A subtropical species of shipworm (*Teredo bartschi*) was first collected at the effluent station in 1975 and has not been found at other sampling stations (ER-OL Section 2.2.2.4).

The rocky shore area in the vicinity of the Millstone site supports a rich and diverse benthic marine community. This community is similar to those of other areas of southern New England and appears to be stable from year to year. Changes in the species list since the sampling began in 1968 seem to be primarily the result of changes in the sampling program. There are variations, however, in the community composition, both spatially and seasonally. Intertidal and shallow-water subtidal areas in the vicinity of Millstone appear to be typical of the Long Island Sound area. The benthic infauna of these areas is typical of these habitats and the abundance, species, composition, and fluctuations in the same reflect diurnal, seasonal, and annual fluctuations in the chemical, thermal, and sedimentological environment. This community is dominated by deposit-feeding oligochaetes and polychaetes. In the Millstone vicinity, the semi-protected area of the intertidal zone, which is dominated by algae and eelgrass detritus, supports a large number of small deposit-feeding oligochaetes. The unprotected areas, which have large sandy areas of medium-grain size and low silt-clay content, are exposed to continuous wave scour. These areas support fewer species and individuals, and they are dominated by larger burrowing polychaetes. The subtidal area is characterized by fine-to-medium-grained sands that support a large number of oligochaetes. The subtidal area of Niantic Bay is characterized by a silty mud substrate and is dominated by the mollusk Nucula proxima (ER-OL Section 2.2.2.4).

Eighteen species found in the intertidal and subtidal areas were considered to be ecologically, commercially, or recreationally important (Table 4.6). Five of these species have been historically of commercial or recreational importance. Neanthes virins (sand worm) and Glycera americana (blood worm) are used for bait by recreational fishermen. Neither species is abundant around the Millstone site. The soft-shell clam (Mya arenaria) is found sporadically in the area. No commercial harvesting of this species occurs in the area. Recent closures because of organic pollution have eliminated most of the recreational use of this species within the Millstone area. Populations of Argopecten irradians (bay scallop) and Mercenaria mercenaria (quahog) are found in the shallow subtidal areas of Jordan Cove. There is no commercial harvesting of these species; however, recreational harvesting occurs in the summer and fall. The ecologically important species (Table 4.6) process detritus and provide an important food source for fish (Arntz, 1980).

The American lobster (Homarus americanus) is the most valuable commercial species within Long Island Sound, yielding 230,000 to 400,000 kg (500,000 to 900,000 pounds) annually at a retail value in excess of $2 million (Phillips and Sastry, 1980). Population dynamics of lobsters have been studied as part of the monitoring program since 1974. The average-size lobster caught in wooden pots (1976-1980) had a carapace length of 73.6 to 76.6 mm. The legal-size lobsters caught in the study areas consisted of 92% newly recruited individuals. The study area is dominated by smaller lobsters and has a smaller legal-size class than that reported for the surrounding area. The lobster population in this area experiences a high level of exploitation, particularly during the summer when recreational fishing is at its peak (ER-OL Section 2.2.2.4).

Approximately 90 fish species have been found in the Millstone area since 1969. Commercially or recreationally important species include Atlantic menhaden, silver hake, white perch, striped bass, butterfish, bluefish, winter flounder, scup, and tautog. Fish that are considered important to the structure or function of the ecosystem in the Millstone area (fish that contribute at least 5% to the demersal, pelagic, or shore-zone collections) are sand lance, killifishes, silversides, winter flounder, windowpane flounder, scup, and cunner (ER-OL Section 2.2.2.5).

Occurrence, location, importance, and spawning of Atlantic menhaden, bluefish, winter flounder, windowpane flounder, tautog, striped bass, blueback herring, Atlantic herring, and Atlantic silverside are discussed in FES-CP Section 2.7.1.3.

The commercial harvest of finfish within an 80-km (50-mile) radius of Millstone is estimated by the staff to be 1.26×10^{7} kg (2.78×10^{7} pounds) a year. The commercial shellfish harvest contributes an additional 6.27×10^{6} kg (1.38×10^{7} pounds), for a total yearly commercial harvest of 1.89×10^{7} kg (4.16×10^{7} pounds). Recreational harvests of finfish and shellfish are 5.82×10^{6} kg (1.28×10^{7} pounds) a year and 1.28×10^{6} kg (2.83×10^{6} pounds), respectively. The annual recreational harvest is 7.10×10^{6} kg (1.57×10^{7} pounds). The total commercial and recreational harvest of shellfish and finfish within an 80-km (50-mile) radius of the Millstone plant is estimated to be 2.60×10^{7} kg (5.73×10^{7} pounds). (See Appendix I of this report for details of the staff's estimation procedures).

4.3.6 Endangered and Threatened Species

4.3.6.1 Terrestrial Species

The small whorled pogonia (*Isotria medeoloides*), an endangered plant, historically occurred in the Towns of Lyme and Glastonbury, Connecticut, through which the transmission corridor from the Millstone facility passes. However, no populations of this plant are known to exist in these towns today. Except for occasional transient individuals of bald eagles (*Haliaetus leucocephalus* and peregrine falcons (*Falco peregrinus*), no other Federally listed or proposed species under the jurisdiction of the U.S. Fish and Wildlife Service are known to exist in the project impact areas (U.S. Department of Interior, 1983).

Several species of birds listed by the State of Connecticut as endangered, declining, or rare (Dowhan and Craig, 1976) have been observed on the Millstone site (ER-OL Table 2.2-4). State endangered species are osprey (*Pandion haliaetus*) and Cooper's hawk (*Accipiter cooperii*); declining species are American bittern (*Botaurus lentiginosus*) and cliff swallow (*Petrochelidon pyrrhonota*); and rare species are the common loon (*Gavia immer*), great egret (*Casmerodius albus*), and the great blue heron (*Ardea herodias*).

4.3.6.2 Aquatic Species

There are no Federally listed threatened or endangered aquatic species in the vicinity of the Millstone plant (U.S. Fish and Wildlife Service, 1983). None of the marine aquatic species reported in the Millstone area are included on the list of endangered and threatened wildlife and plants (U.S. Department of Interior, 1983).

4.3.7 Community Characteristics

The socioeconomic descriptions of the area--including demography, land use, and community characteristics in general--are in FES-CP Sections 2, 4, 5, and 11.

Millstone 3 is located in the Town of Waterford, which had a 1980 population of 17,843. The 202-ha site, on the tip of Millstone Point between Niantic Bay on the west and Jordan Cove on the east, is 5.1 km (3.2 miles) west-southwest of New London, Connecticut (1980 population 28,842) and 64 km (40 miles) southeast of Hartford (1980 population 136,392).

The applicant estimates the 1980 population within 16 km (10 miles) of the plant to have been 109,437 and projects it will be 127,513 in the year 2020.

The staff has reviewed the applicant's demography data within 16 km (10 miles) and found it compares favorably with data from independent sources.

The transient population of the area is composed of individuals associated with industrial, institutional, and recreational facilities. The employers located within 10 km (6 miles) of Millstone having more than 50 employees account for about a total of 25,000 employees. Of these, almost 21,000 persons are employed at the Electric Boat Division of General Dynamics Corporation in Groton, Connecticut, about 8 km (5 miles) east-northeast of the site; slightly fewer than 3000 work at Pfizer, Inc., also in Groton. Nearby institutions include educational, health care, and correctional facilities. The majority of students within 10 km (6 miles) of the site are residents of the area and do not add greatly to the population. There is a 325-bed, 1200-staff-member hospital in New London. Within 10 km there are five nursing homes with more than 50 beds each, with a total of 560 beds. There is a correctional institute 6.2 km (3.9 miles) west-northwest of the site that has 300 inmates, 170 full-time employees, and fewer than 10 part-time employees. Although there are beaches and recreational facilities in the area, many are used by residents and do not generate any significant increase in population. Seasonal population variations resulting from an influx of summer residents is minimal.

There have been no other significant changes in these topics from the descriptions in the FES-CP.

4.3.8 Historic and Archeologic Sites

FES-CP Section 2.3 describes historic and archeologic sites in the area. New information developed since the issuance of the FES-CP consists of additional properties listed or determined eligible for listing in the National Register of Historic Places. Appendix H contains a listing of such properties within about 16 km (10 miles) of the site. With regard to the Millstone-to-Manchester 345-kV transmission line, the only site listed or eligible for listing on the National Register near the line is the Lebanon Green Historic District, 457 m (1500 feet) east of the route. The applicant has provided right-of-way development and management plans for all segments of the line to the Connecticut Siting Council and to the State Historic Preservation Officer.

4.4 References

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Phillips, B. F., and A. N. Sastry, "Larval Ecology," in J. S. Cobb and B. F. Phillips, The Biology and Management of Lobsters, Vol 2, Ecology and Management, Academic Press, New York, 1980.

U.S. Department of Interior, "Endangered and Threatened Wildlife and Plants, 50 CFR 17.11 and 17.12," July 27, 1983.

U.S. Fish and Wildlife Service, letter from Gordon E. Beckett, Ecological Services, Concord, NH, to B. J. Youngblood, NRC, March 10, 1983.

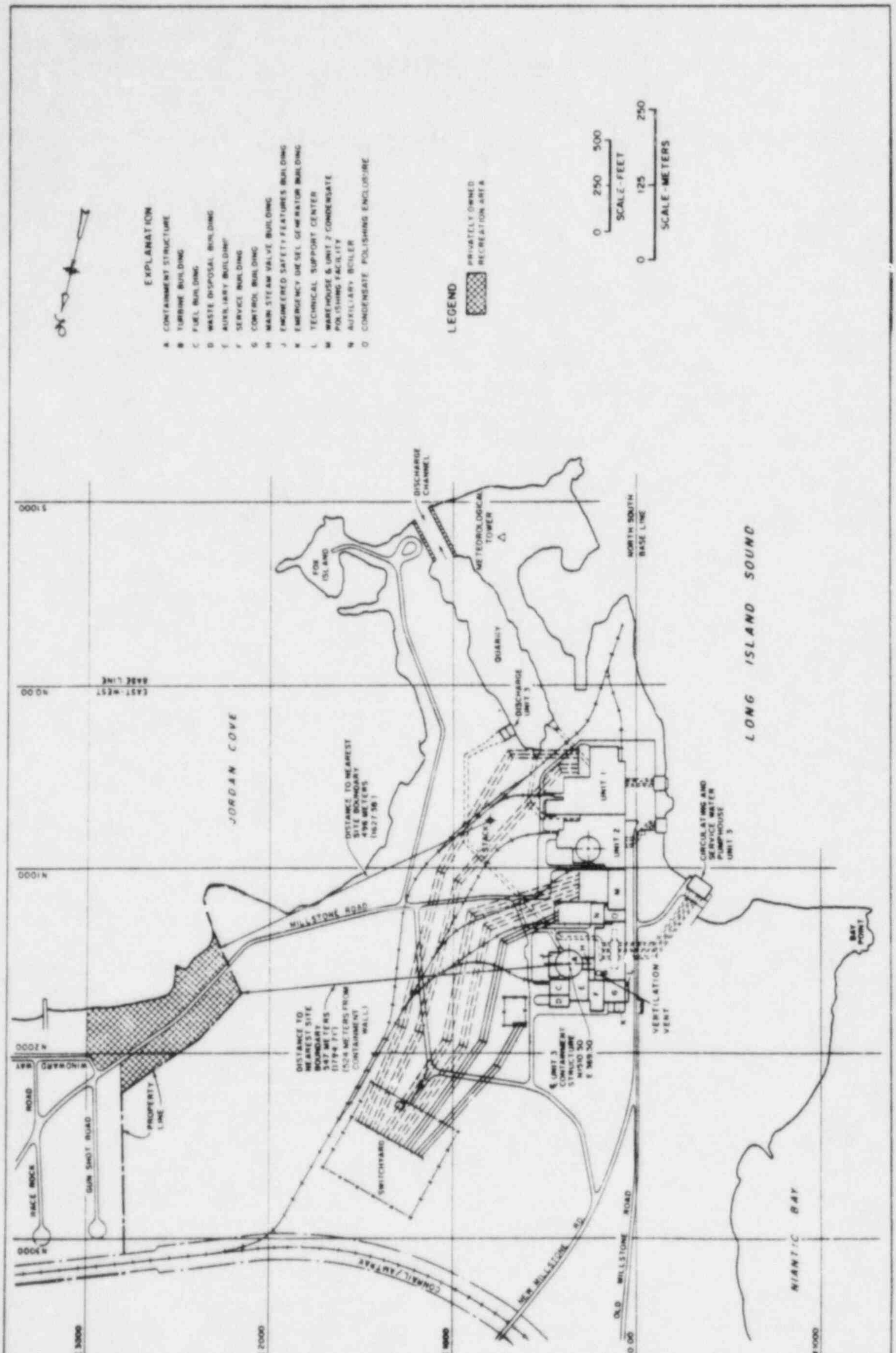
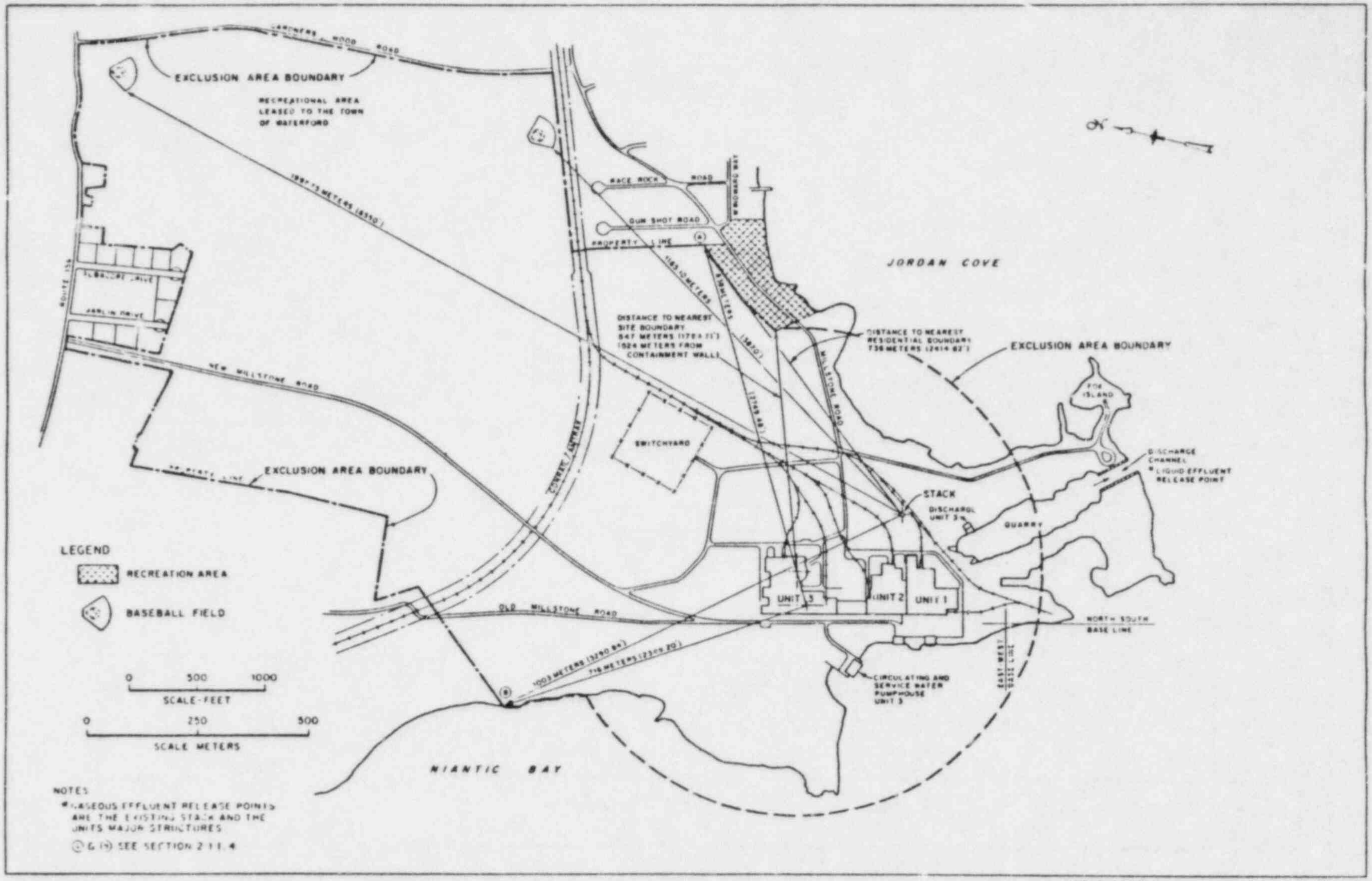


Figure 4.1 Millstone Unit 3 site plan
Source: ER-OL Figure 2.1-4



NOTES
* GASEOUS EFFLUENT RELEASE POINTS ARE THE EXISTING STACK AND THE UNITS MAJOR STRUCTURES
Ⓐ & Ⓑ SEE SECTION 2.1.1.4

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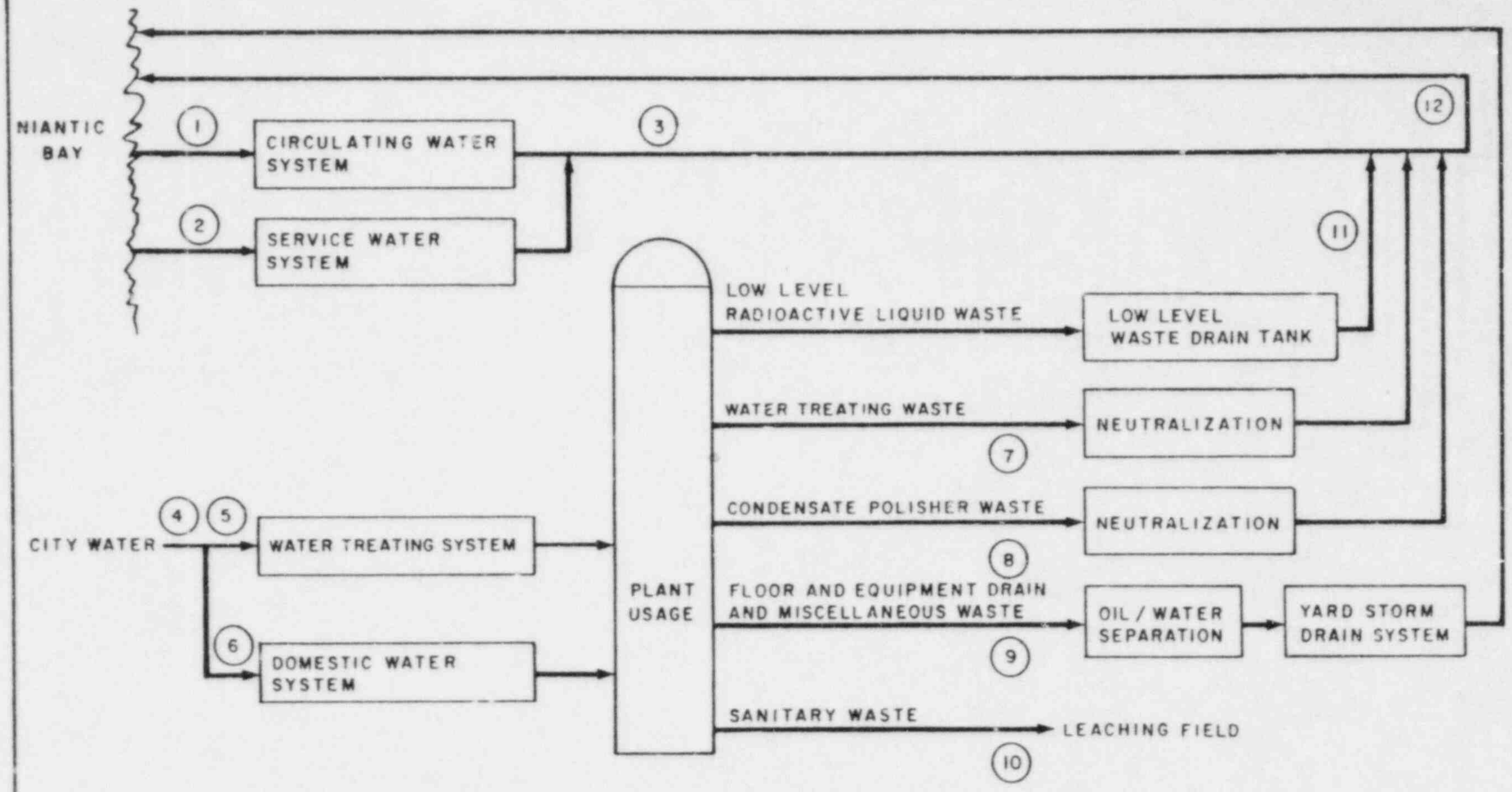
Figure 4.2 Millstone Unit 3 site layout
Source: ER-OL Figure 2.1-3



NOTE: Item numbers correspond to those in Table 4.1

Figure 4.3 Station water use
Source: ER-OL Figure 3.3-1

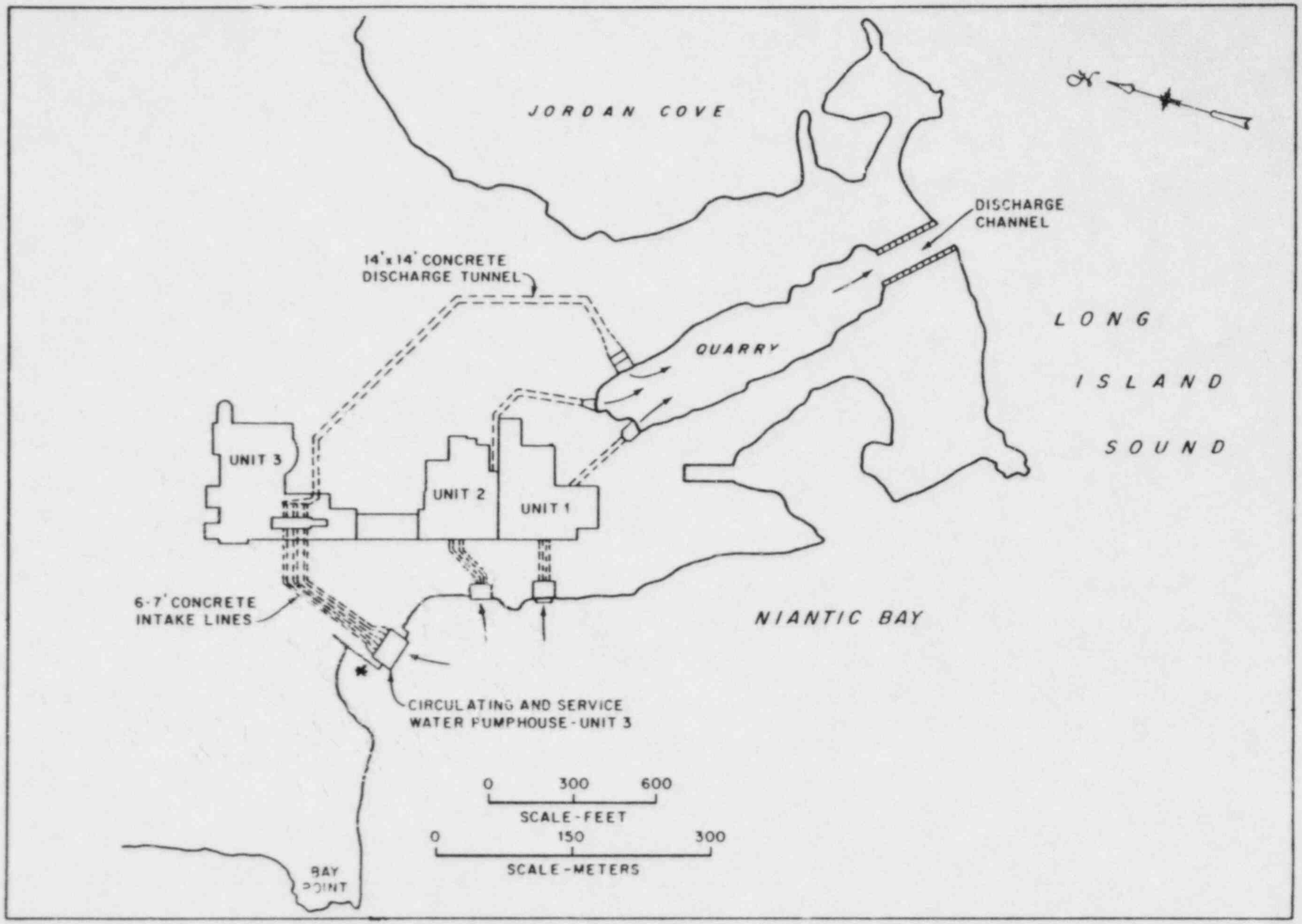


Figure 4.4 Circulating water system
Source: ER-OL Figure 3.4-2

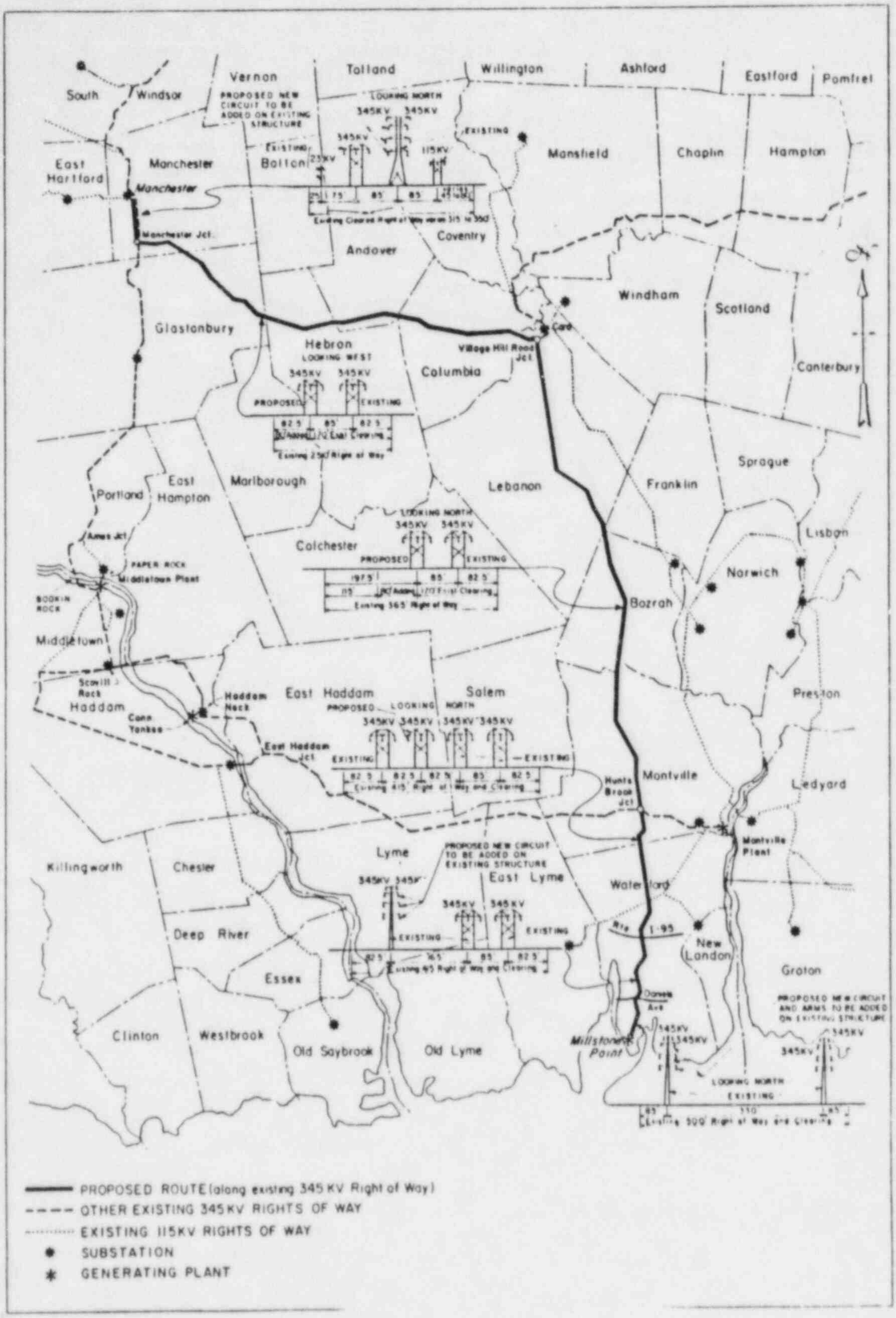


Figure 4.5 Millstone Unit 3 location map
Source: ER-OL Figure 3.9-2

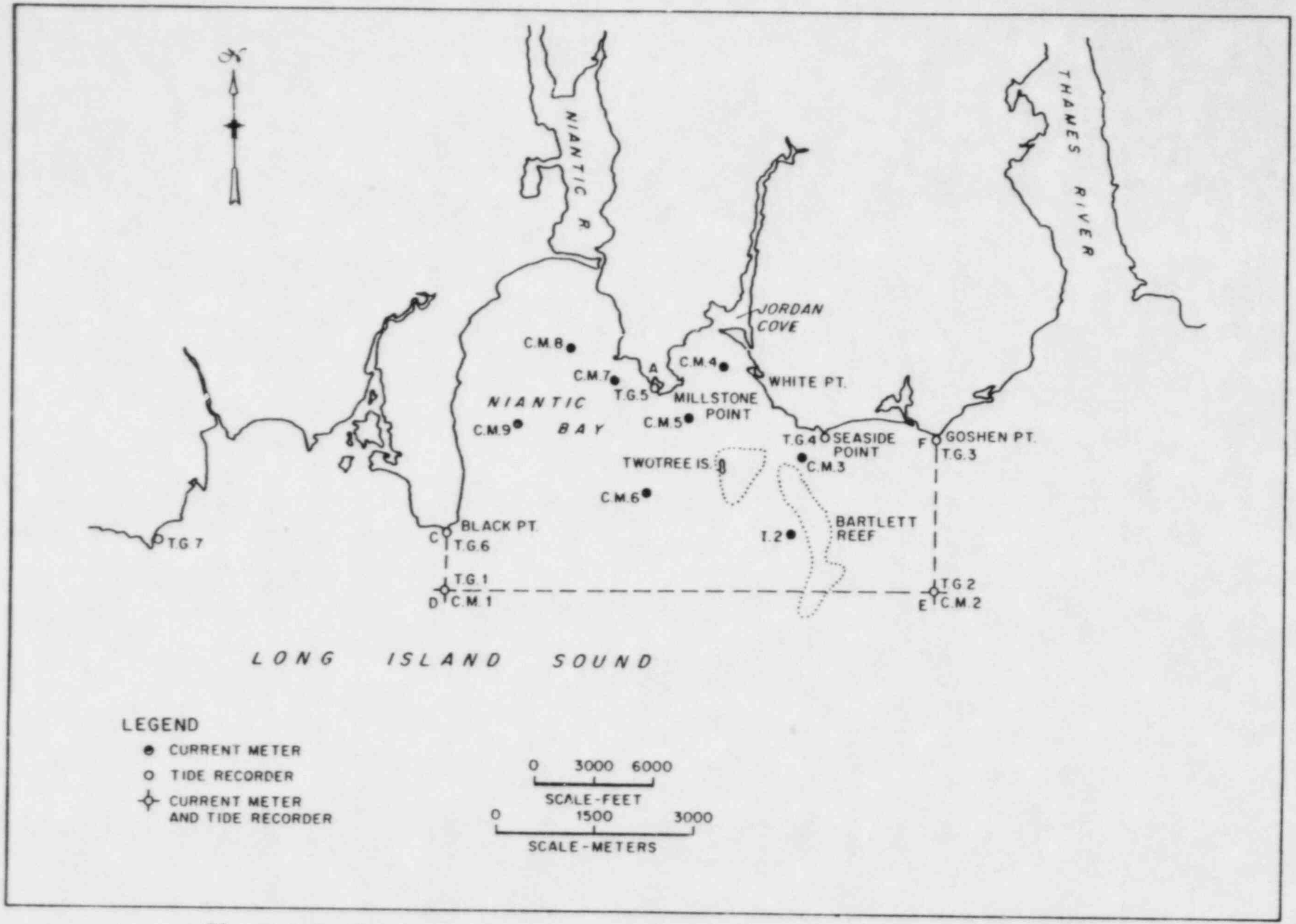


Figure 4.6 Field survey stations, approximate locations, February 1974
Source: ER-OL Figure 2.4-7

Table 4.1 Station water use

Item*	Maximum** (gpm)	Average (gpm)	Minimum** (gpm)
1. Circulating water from Niantic Bay	912,000	912,000	0
2. Service water from Niantic Bay	29,410	29,410	11,854***
3. Total cooling water	941,410	941,410	11,854***
4. Total city water withdrawal	500	100	0
5. Water treating system	265	58	0
6. Domestic water system	235	42	0
7. Water treating waste	200	3.2	0
8. Condensate polisher waste	200	14	0
9. Floor and equipment drain and miscellaneous waste	100	40	0
10. Sanitary waste	9.7	2.4	0
11. Discharge from radioactive liquid waste treatment	50	0.5	0
12. Total circulating water discharge	941,960	941,470	11,854

NOTES:

To convert to m^3/s, multiply gpm by 6.3×10^{-5}.

*Item numbers correspond to the numbers on Figure 4.2.

**Neither maximum nor minimum extremes are expected to occur simultaneously.

***Flows occur during a temporary shutdown.

Source: ER-OL Table 3.3-1.

Table 4.2 Service water flow and heat load requirements

Requirement	Normal Operating Condition	Normal Unit Cooldown Condition
Flow (gpm)	27,288	27,426
Flow (lb/hr)	1.516×10^7	1.523×10^7
Heat load (10^6 Btu/hr)	213.72	235.74
ΔT°C (F)	8.2 (14.8)	9.1 (16.3)

NOTES:

To convert gpm to L/min, multiply values shown by 3.785.

To convert lb/hr to kg/hr, multiply values shown by 0.454.

To convert 10^6 Btu/hr to 10^6 J/hr, multiply values shown by 1055.

Source: ER-OL Table 3.4-1.

Table 4.3 Chemical additions to water used for station operation

Chemical Use and System Involved	Reason for Use or Source of Chemical	Estimated Monthly Quantities (lb/mo)				Frequency of Chemical Addition
		Addition to System		Station Discharge		
		Average	Maximum	Average	Maximum	
Boron (as B):						
Reactor coolant system	Soluble neutron adsorber	20,000 lb/yr	NA	0.86	0.17 lb/day	NA
Chromates (as K_2 CrO_7):						
Neutron shield tank cooling	Corrosion control	10 lb/yr	NA	None	None	NA
Ammonia (as NH_3 (25%):						
Reactor plant component cooling water, charging pumps cooling, safety injection pumps cooling	Corrosion control	90 lb/yr	NA	None	None	NA
Auxiliary steam and condensate	Corrosion control	6	12	None	None	Continuous
Steam and power conversion	Corrosion control	26,100	27,900	None	None	Continuous
Hydrazine (as N_2H_4) (40%):						
Auxiliary steam and condensate	Corrosion control	62.5	125	None	None	Continuous
Steam and power conversion	Corrosion control	735	870	None	None	Continuous
Chilled water system	Maintain pH; control O	7.5	12.5	None	None	Once per day
Chlorine (as Cl_2):						
Service water system	Biofouling control	507.6	1268.7	507.6	1268.7	3 times per day

Source: ER-OL Table 3.6-1

Table 4.3 (continued)

Chemical Use and System Involved	Reason for Use or Source of Chemical	Estimated Monthly Quantities (lb/mo)				Frequency of Chemical Addition
		Addition to System		Station Discharge		
		Average	Maximum	Average	Maximum	
Sodium Hypochlorite (as Cl_2 (15%):						
Makeup ultrafiltration system	Ultrafiltration cleaning cycle	1,070	4,270	1,070	4,270	Once per day
Sulfuric Acid (as H_2SO_4) (100%):						
Makeup demineralizer equipment	Regeneration of ion exchange resins	11,600	23,200	11,600	23,200	Once every 3 days
Condensate polishing mixed bed	Regeneration of ion exchange resins	6,200	49,300	6,200	49,300	Once every 4 days
Sodium Hydroxide (as NaOH) (50%):						
Makeup demineralizer equipment	Regeneration of ion exchange resins	17,800	35,600	17,800	35,600	Once every 3 days
Condensate polishing mixed bed	Regeneration of ion exchange resins	4,800	37,800	4,800	37,800	Once every 4 days
Makeup ultra-filtration system	pH adjustment	NA	NA	NA	NA	As necessary
Lime (as $Ca(OH)_2$) (100%):						
Condensate polishing mixed bed	Regeneration of ion exchange resins	400	3,200	400	3,200	Once every 4 days
Sodium Sulfite (as Na_2SO_3) (100%):						
Waste treating system	Neutralization of sodium hypochlorite	270	1,084	270	1,084	Once per day
Dow Binder:						
Radioactive solid waste	Waste solidification agent	32,500 lb/yr	40,000 lb/yr	None	None	Once per year

Table 4.3 (continued)

Chemical Use and System Involved	Reason for Use or Source of Chemical	Estimated Monthly Quantities (lb/mo): Addition to System: Average	Estimated Monthly Quantities (lb/mo): Addition to System: Maximum	Estimated Monthly Quantities (lb/mo): Station Discharge: Average	Estimated Monthly Quantities (lb/mo): Station Discharge: Maximum	Frequency of Chemical Addition
Dow Catalyst:						
Radioactive solid waste	Waste solidification agent	800 lb/yr	1,000 lb/yr	None	None	Once per year
Dow Promoter:						
Radioactive solid waste	Waste solidification agent	32 lb/yr	40 lb/yr	None	None	Once per year

NOTE:

NA = Not available

Table 4.4 Baseline water quality data, Long Island Sound* quarterly sampling

Parameter*	March	June	September	December
Total alkalinity	230	237	236	257
Chloride	17,182	17,045	17,955	18,352
Potassium	577	588	496	636
Calcium	263	259	234	232
Magnesium	781	1,441	1,120	852
Arsenic	ND	ND	ND	ND
Molybdenum	0.33	<0.5***	0.045	ND
Titanium	ND	ND	ND	<0.19***
Vanadium	0.16	<0.16***	0.016	ND
Cadmium	0.03	0.05	<0.013***	ND
Beryllium	ND	ND	ND	ND
Mercury	ND	ND	ND	ND
Total solids	33,203	35,418	33,742	33,510
Volatile solids	5,810	7,732	7,217	5,109
Tin	11.0	ND	<0.3***	ND
Phenol	ND***	ND	<0.003***	ND

NOTES

ND-Not detectable.

*Based on data collected during the 1974 water quality monitoring program

**All concentrations are expressed in mg/L.

***For those parameters where one or more reported values were below detection limits, concentrations shown are averages of values greater than these limits.

Source: ER-OL Table 2.4-3.

Table 4.5 Monthly average total metal concentration*

		Unfiltered Samples (mg/L)				
Month	Tide	Iron	Manganese	Nickel	Zinc	Aluminum
Jan	Ebb	0.16	0.03	0.104	0.009	1.01
	Flood	0.16	0.01	0.069	0.011	1.34
Feb	Ebb	0.08	0.017	0.083	0.003	0.6
	Flood	0.09	0.021	0.075	0.004	0.7
Mar	Ebb	0.14	0.043	0.24	0.012	1.2
	Flood	0.14	0.045	0.25	0.009	1.4
Apr	Ebb	0.13	0.037	0.11	0.011	1.2
	Flood	0.11	0.039	0.13	0.008	0.9
May	Ebb	0.14	0.03	0.16	0.045	0.64
	Flood	0.14	0.02	0.17	0.035	1.00
June	Ebb	0.08	0.026	0.12	0.007	0.28
	Flood	0.08	0.031	0.11	0.006	0.29
July	Ebb	0.09	0.03	0.09	0.026	3.7
	Flood	0.08	0.03	0.09	0.025	2.3
Aug	Ebb	0.05	0.023	0.024	0.004	0.7
	Flood	0.03	0.019	0.019	0.005	0.7
Sept	Ebb	0.14	0.022	0.042	0.005	1.6
	Flood	0.14	0.019	0.049	0.006	0.5
Oct	Ebb	0.05	0.008	0.04	0.011	<0.2
	Flood	0.05	0.012	0.01	0.012	<0.2
Nov	Ebb	0.01	0.006	0.01	0.016	<0.2
	Flood	0.01	0.006	0.02	0.017	0.28
Dec	Ebb	0.04	<0.005	<0.005	0.021	0.3
	Flood	0.03	<0.005	<0.005	0.015	0.3

*Based on data collected on ebb and flood tides during the 1974 water quality monitoring program.

Source: ER-OL Table 2.4-4.

Table 4.6 Most dominant and commercially or recreationally important infaunal species in the Millstone Point area

---

Annelida

Oligochaeta
Polychaeta:

- *Aricidea catherinae*
- *Chaetozone* spp.
- *Polycirrus eximius*
- *Mediomastus ambiseta*
- *Capitella* spp.
- *Neanthes virens*
- *Scolecolepides viridis*
- *Paraonis fulgens*
- *Haploscoloplos acutus*
- *Haploscoloplos fragilis*
- *Glycera americana*

Arthropoda

- *Ampelisca verrilli*

Mollusca:

- *Nucula proxima*
- *Mya arenaria**
- *Tellina agilis*
- *Mercenaria mercenaria**
- *Argopecten irradians**

Rhynchocoela

---

*Of commercial or recreational importance only.

Source: ER-OL Table 2.2-35.

5 ENVIRONMENTAL CONSEQUENCES AND MITIGATING ACTIONS

5.1 Résumé

This section updates the information on environmental consequences and mitigating actions presented in the FES-CP.

No changes in the minimal impacts on land use are expected (Section 5.2). In general (Section 5.3.1) no impact on water use is expected; however, updated and expanded data on thermal and quality effects on area waters are presented in Sections 5.3.1.2 and 5.3.1.3. The staff's conclusion that there will be no adverse hydrologic impact remains valid (Section 5.3.3), as does its conclusion that the effect on the 100-year floodplain will be negligible.

Recent studies regarding terrestrial effects, discussed in Section 5.5.1, show minimal adverse effects are expected. Section 5.5.2 describes how effects on the aquatic resources in the plant area will be minimized because of the addition of sluiceways and the shoreline location of the intake structure. Although the staff does not expect any impact on historic or archeologic areas from the operation of Unit 3, investigation of possible impacts along the transmission corridor are ongoing (Section 5.7). The only change in projected socioeconomic impact is a slight increase in work force, which is not expected to be a significant impact (Section 5.8). Updated general information on radiological impacts, still expected to be minimal, is in Section 5.9. The staff's evaluation of the Millstone plant-specific probabilistic safety study of severe accidents is presented in Section 5.9.4.

An updated general discussion of the uranium fuel cycle impacts is in Section 5.10, with plant-specific details presented in Appendix C.

Section 5.12 presents the results of a recent evaluation of noise impacts, including a specific discussion regarding noise complaints made by two area residents.

Regarding emergency planning impacts, Section 5.13 notes that because Unit 3 will use facilities already constructed for Units 1 and 2, no additional impacts are expected.

In Section 5.14.1, the staff discusses why terrestrial monitoring is no longer considered necessary. Section 5.14.2 notes that the operational aquatic monitoring requirements are the same as the preperational requirements, and describes a change in sampling procedures proposed by the applicant.

5.2 Land Use

5.2.1 Plant Site and Vicinity

The staff evaluated impacts of Unit 3 operation on land use in FES-CP Section 5.1. Only minimal impacts were predicted, and that evaluation remains valid. Construction and operation of Unit 3 will require a permanent commitment of only about 4.9 ha (12 acres) of additional land. Other land used temporarily during construction will be reseeded. Some beach area formerly available to the public at Bay Point will be occupied by the intake pumphouse.

The Federal Coastal Zone Management Act and the Connecticut Coastal Area Management Act define tidal wetlands and related estuarine resources as national interest facilities. Thus, the existing tidal wetland on the Millstone site property is protected by state law and has been designated as a natural resource by the Town of Waterford's Plan of Development. Consistent with these policies, the wetland and its immediate surroundings are being managed as a wildlife area by the applicant.

5.2.2 Transmission Lines

Land use along transmission lines is not expected to change as a result of station operation. Agricultural uses can continue under and along the lines; only the small areas under the tower bases cannot be farmed. The potential impacts of transmission line operation on terrestrial biota and humans are discussed in Section 5.5.

5.3 Water-Use and Hydrologic Impacts

5.3.1 Water Use Impacts

5.3.1.1 General

The major water use associated with Unit 3 operation is withdrawal of approximately 57 m^3/sec (2000 cfs) of water for once-through cooling of the main steam condensers and various heat exchangers within the plant. This cooling water will be withdrawn from Niantic Bay and will be discharged through the onsite quarry into Long Island Sound. Because of the size of Niantic Bay, the Sound, and the Atlantic Ocean relative to the thermal discharge from Unit 3, there should be no impact on water use as the result of cooling water withdrawal from and return to Niantic Bay.

Fresh water for use by the domestic water system, auxiliary boiler, condensate storage, and auxiliary feedwater system will be supplied by the town of Waterford's public water system. Approximately 13,250 L/day (3500 gpd) will be consumed for potable and sanitary purposes. At a projected discharge of 75 L/day (20 gpd) per person to the septic system, this water use is well below that projected for average consumption per capita. This water use would constitute less than 1% of the water use of the Town of Waterford (1980 population approximately 4500 (Rand McNally, 1980)). Approximately 25,525 L (7800 gallons) will be consumed annually for processing radioactive solid waste.

5.3.1.2 Thermal Effects

The temperature of the discharge from Units 1 and 2 is about 12.8C° (23.0F°) above ambient. The addition of the discharge from Unit 3 at a temperature of 9.4C° (17.0F°) above ambient (Section 4.2.3) will decrease the overall temperature of the discharge by approximately 0.8C° (1.4F°). Therefore, the cooling water discharge from three-unit operation will increase the water temperature about 11.9C° (21.4F°) above ambient at the discharge from the quarry to Long Island Sound.

Examination of the applicant's thermal plume predictions (Witten, 1984) indicates that the estimated size of the thermal plume and the estimated extent of the isotherms presented by the applicant were accurate; however, the staff's calculated directions of the thermal plume under flood and ebb tide differed from that calculated by the applicant (ER-OL, Section 5.1).

The primary zone of mixing was determined for the applicant by Stolzenbach and Adams (1979) to occur within 300 m (1000 feet) of the quarry cut. Within this mixing area, organisms will be exposed to temperature increases of 6C° to 10C° (11F° to 18F°). The estimated thermal plume volume with temperatures of 6C° (11F°) and greater above ambient is 2.0×10^4 m^3 (7×10^5 ft^3) (ER-OL Section 5.1.3). On the basis of three-unit operation and an estimated discharge from the quarry of 123.3 m^3/sec (4400 cfs), the exposure time of plume-entrained organisms to a temperature increase of 6C° (11F°) or greater would be less than 3 minutes.

Discharge from the quarry to Long Island Sound at an approximate rate of 123.3 m^3/sec (4400 cfs) and at an elevated temperature of 11.9°C (21.4F°) above ambient will entrain colder Sound water, which will reduce the temperature increase of the thermal plume. The estimated extent of the thermal plume with three units operating is shown in Table 5.1. The thermal plume at the 1C° (2F°) isotherm will cover most of Niantic Bay.

5.3.1.3 Water Quality

The waters of Long Island Sound in the vicinity of the Millstone nuclear plant are classified as class SB* by the State of Connecticut Department of Environmental Protection (1977). A summary of the class SB standards is given in Table 5.2. The NPDES permit requirements for effluent limitations are designed to protect the waters of Long Island Sound for these uses. The NPDES permit is reproduced in Appendix G, and a summary of the effluent limitations is given in ER-OL Table 5.3-2.

The chemical composition of the water discharged to the quarry after once-through cooling is essentially the same as that drawn into the plant at the circulating and service water pumphouse. The primary liquid wastes discharged from the unit are the chemical wastes resulting from the regeneration of the makeup water demineralizers and the condensate polishing demineralizers.

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*"... suitable for bathing, other recreational purposes, industrial cooling, and shellfish harvesting for human consumption after depuration; excellent fish and wildlife habitat; good aesthetic value."

Table 5.3 shows Long Island Sound water quality data collected during 1974 for comparison with effluent concentrations from Unit 3. An average of approximately 242,000 L (64,000 gallons) a week of regeneration wastes from the makeup demineralizer system will be neutralized (pH 6.0 to 9.0 standard units) and discharged to the circulating water discharge tunnel. The primary constituents of this discharge are sodium and sulfate, the result of sulfuric acid and sodium hydroxide addition. These chemicals will occur in concentrations of 1,460 mg/L (sodium) and 3,230 mg/L (sulfate). The concentration of sulfate in the regeneration waste discharge is approximately 790 mg/L greater than in the intake water (ER-OL Section 3.6.1). At a circulating water discharge of 57 m^3/sec (2000 cfs) and a discharge from the regeneration system to the circulating water tunnel of 6.3×10^{-3} m^3/sec (0.22 cfs), the increase in concentration of sulfate in the circulating water discharged to the quarry would be approximately 0.1 mg/L. Any effect of discharge of this increased sulfate concentration from the quarry to Long Island Sound should be minimal.

The concentrations of sodium and sulfate in the discharge from the condensate polisher demineralizer to the circulating water system are projected to be 1770 mg/L and 3930 mg/L, respectively (ER-OL Section 3.6.1). This is an increase in sulfate concentration in the circulating water discharge of less than 0.1 mg/L.

Biofouling in the condenser will be controlled by a mechanical cleaning system (Section 4.2.4.1); consequently, chlorination of the circulating water system is not anticipated. The service water system is, however, chlorinated with the chlorination rate monitored and controlled by a residual chlorine analyzer to ensure that the residual oxidant concentration at the discharge to the circulating water system is less than 0.1 mg/L (ER-OL Section 3.4.2). After mixing with water in the circulating water tunnel and the quarry, the oxidant demand of these water sources should reduce the level of free available oxidant to below detection limits. As a result, only trace levels will be discharged to Long Island Sound.

Millstone Unit 3 uses copper/nickel condenser tubes with sacrificial zinc blocks used as corrosion inhibitors for once-through condenser cooling. A study conducted during 1979 (Waslinchuk, 1980) determined the impact of condenser tube corrosion on trace metal concentrations in Long Island Sound based on operation of Units 1 and 2. Samples were collected at the intake and outfall, along the discharge plume axis and either side of the plume, and two locations 2 km to either side of Millstone Point to determine ambient far-field concentrations.

Results of this study, which are summarized in Table 5.4, showed that the majority of the increases in trace metal concentrations were in the particulate fraction and were attributed to the plant cooling system. Analysis of the water samples collected along the discharge plume axis indicates that the added metal concentrations in the plant discharge disperse in a way that is similar to the way heat disperses (ER-OL Section 5.3.4). The values found in this study (Waslinchuk, 1980) were within the range of values from the 1973 to 1980 monitoring program.

The values for copper, nickel, and zinc in the vicinity of the plant do not exceed water quality criteria for protection of marine biota. Conservative levels for protection of aquatic biota are 1.8 μg/L for copper, 3.1 μg/L for nickel, and 4.2 μg/L for zinc (EPA, 1976). The dissolved concentration of copper at the plant outfall and total concentrations of all three metals at the plant discharge to the quarry exceed the water quality criteria; however, after dilution within the quarry they are within limits for protection of aquatic biota.

5.3.2 Hydrologic Impacts

5.3.2.1 Coastal Water

As described above, the Millstone 3 cooling and service water supply comes from Niantic Bay. The once-through circulating water system withdraws cooling water from the bay at the rate of 57.5 m^3/s (2032 cfs) and discharges it back into Long Island Sound through the quarry pond. The regional use of the adjacent coastal water is mainly for recreation, including watersports, fishing, and boating.

The staff has concluded that operation of Millstone 3 will not have an adverse effect on the regional water use from Niantic Bay and Long Island Sound, primarily because of the large volume of seawater available for both plant operation and recreational use.

5.3.2.2 Surface Water

The public water supplies within a 32-km (20-mile) radius of the site are identified on Figure 5.1. The nearest surface public water supply is the New London Water Department's Lake Komac, 9.2 km (6 miles) north-northwest of the site. No surface drainage from the plant site could affect this reservoir because of the distance involved, the intervening surface elevations (topography), the expected groundwater gradient from the reservoir area to the site, and the generally impervious nature of the overburden on and near the site. Thus, the staff has concluded that the operation of Millstone 3 will not have an adverse effect on regional use of public water supplies.

5.3.2.3 Groundwater

Virtually all the potable water used within an 8-km (5-mile) radius from the containment structure is groundwater. The fresh water supply for the operation of Millstone station comes from the Town of Waterford's public supply system, which utilizes a groundwater source.

As discussed in Section 4 above, there are three onsite shallow wells (Figure 5.2), all of which are up gradient from the containment structure. One is about 2.0 km (6600 feet) to the north-northeast; one is about 1.2 km (4000 feet) to the northeast; and the third is about 0.55 km (1800 feet) to the northwest. None of these onsite wells provide domestic drinking water or water for plant operation; the well 1.2 km northeast is used seasonally to supply drinking water to a nearby baseball field. The nearest wells used by the public are about 3.2 km (2 miles) groundwater up gradient from the containment structure.

The staff has concluded that the operation of Millstone 3 will not have an adverse effect on the domestic use of groundwater, because all wells are up gradient from the containment structure.

5.3.3 Floodplain

Construction at the site on Unit 3 had already begun when Executive Order 11988, Floodplain Management, was signed in May 1977. Thus, consideration of alternative locations for any structures identified as being in the floodplain is neither required nor practical.

The floodplain is defined as the lowland and relatively flat areas adjoining inland and coastal waters that are subject to a 1% or greater chance of flooding in any given year. For the Millstone 3 site, the floodplain (shown in Figure 5.3) is the low lying area adjacent to the surrounding tidal shoreline to the east, south, and west of the plant. Flooding at the site would be caused by either intense precipitation or a storm surge caused by northeasters or hurricanes.

The 100-year flood was conservatively estimated to be 3.3 m (10.7 feet) msl using the Federal Insurance Administration (FIA) Flood Insurance Study for the Town of Waterford. Table 5.5 compares the 100-year flood level at the site and other floods either estimated or measured for the site and other nearby coastal areas.

Areas inundated by the 100-year flood are shown on Figure 5.3, which also shows areas where site construction has disturbed the preconstruction 100-year floodplain. Because most of the plant area is above the 100-year floodplain, the encroachment of the plant site on the floodplain will have no measurable hydrologic effects on the flood level elsewhere. Furthermore, the plant has been designed for floods far more severe than the 100-year flood, up to and including the probable maximum floods from storm surge and precipitation runoff. The only direct effect of the site on the floodplain is the removal of a small amount of habitat below the 3-m msl contour in the area of the intake structure, the discharge structure in the quarry, and the enlarged quarry outlet shown on Figure 5.3.

Thus, the staff considers that the effect of the presence or operation of the plant on the 100-year floodplain will be negligible.

5.4 Air Quality

Air quality in the site vicinity is generally good, and operation of the fossil-fueled auxiliary boilers and diesel generators will not adversely affect that situation. The gaseous nonradioactive effluents will be comprised of particulate matter, hydrocarbons, and oxides of sulfur, nitrogen, and carbon. These are the normal products of combustion of fossil fuels.

The limited operation of these sources will result in air concentrations off site being below the Federal and state air quality standards.

5.4.1 Fog and Ice

The plant, which uses Long Island Sound for once-through cooling, should not produce any fog or ice in the area.

5.4.2 Other Emissions

Other sources of atmospheric emissions are exhausts from vehicles and possible dust from traffic on unpaved roads. These emissions should have a minimal impact off site.

On the basis of information provided by the applicant and staff experience with evaluation of other similar facilities, the staff concludes that the infrequent operation of these sources should not result in a significant impact on the air quality in the vicinity of the plant.

5.5 Ecology

5.5.1 Terrestrial Ecology

5.5.1.1 Plant Site and Vicinity

Operation of Millstone 3 is not expected to have adverse impacts on terrestrial ecology. Beneficial impacts will continue to accrue from the maintenance of osprey nesting platforms and protection of 20 ha (50 acres) of ponds, salt marsh, and woods at the wildlife management area onsite. Locating an additional unit at an existing plant site will result in mimimal long-term loss of wildlife compared to construction and operation of a new plant.

5.5.1.2 Transmission System

Potential impacts of operation of the transmission system include corona effects, induced electric and magnetic fields, bird collisions, and effects resulting from maintenance of the corridors.

Corona is noticeable primarily on voltage lines of 500-kV and higher, especially during wet weather, but it also occurs at lower voltages. Corona may result in audible noise, radio and television reception interference, light, and production of ozone and oxides of nitrogen (NO_x). The concentration of corona-produced ozone is usually less than the daily natural variation in ozone concentration (Lee et al., 1982), and adverse impacts consequently are unlikely. Production of oxides of nitrogen is similarly insignificant.

Equipment such as tractors operated or parked under the lines can develop a static charge that may cause a slight sensation or shock at a person's touch. Ungrounded fences and gates can develop charges that will deliver a painful shock to a grounded individual touching them (Lee et al., 1982). However, such occurrences are relatively rare near 345-kV lines. If property owners complain of such problems, the applicant will ground the objects to eliminate the possibility of painful shock.

Electric fields on the existing 345-kV line have been measured at a maximum of 8 kV/m (ER-OL Section 5.5.4). The applicant estimates that maximum fields at the edge of the right-of-way will not exceed 1.6 kV/m, with the new line present (ER-OL Section 5.5.4). Research on effects of electric fields on humans and other organisms has produced various results (Lee et al., 1982). For the most part, adverse effects have been shown only for higher fields (e.g., greater than 15 kV/m), or longer exposure times than would occur for people residing near or working for extended periods under transmission lines. Also, some of the studies purporting to demonstrate adverse effects used poor experimental design or inadequate statistical treatment of results (Lee et al., 1982).

Results of research studies on electric field effects on growth and development of plants and animals indicate that neither serious injuries nor 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.

Collisions of birds with power lines are most evident where lines pass through areas with large concentrations of birds, such as reservoirs and certain agricultural fields. Studies of mortality of waterfowl under such conditions suggest that less than 0.07% of total nonhunting waterfowl mortality is caused by power lines (Stout and Cornwell, 1976). At Millstone, ospreys, some waterfowl, and large wading birds occur in the wildlife management area, and there is consequently some potential for birds colliding with the power lines leaving the plant. These lines enter the switchyard west of the most heavily used habitats (marsh, pond, and coast) and major flight pathways; hence the number of collisions is likely to be small, and impacts on bird populations are expected to be negligible.

Transmission line maintenance requires that vegetation be controlled so it will not interfere with the safe and reliable operation of the line or impede restoration of service when outages occur. Vegetation will be controlled by selective, basal application of herbicides. Only herbicides registered for such use with the EPA will be employed. Treatments will be applied at 5- to 8-year intervals and, on the average, only about 2.0 to 3.0 kg of herbicide per hectare of brush (1.8 to 2.7 lbs/acre) will be applied (ER-OL Section 5.5.2). All herbs, most shrubs, and low-growing trees such as dogwood are normally allowed to grow on the right of way. This method has been commonly and successfully used by the applicant and other utilities in the eastern U.S. Properly implemented, the method produces a relatively stable low-growing cover with minimal disturbance to wildlife during periodic maintenance (Bramble and Byrnes, 1974; Carvell and Johnston, 1974). In wooded country, which is the predominant character along the right of way, such actions usually increase the diversity of plant and animal species using the area. Hence, impacts of transmission line maintenance on wildlife are expected to be minor.

5.5.2 Aquatic Resources

Aquatic resources in the vicinity of the Millstone plant will be subject to physical, chemical, and thermal effects of the cooling system operation. Organisms in the vicinity of the intake structure may be susceptible to impingement on the traveling screens, although potential impact of impingement will be mitigated by return of impinged organisms via a sluiceway to Niantic Bay. Entrainment effects will be minimized by the design of the intake structure and the absence of chlorine in the circulating water system. Those organisms in the vicinity of Twotree Island Channel, Niantic Bay, and the lower portions of Jordan Cove will experience localized effects from the thermal plume and chemical discharge.

Chemical and Biocide Discharges

Chemical constituents in the discharge from Unit 3 are increased by only a small amount above ambient as the result of regeneration of the makeup and condensate polisher demineralizers (Section 5.3.1 above). Because of the small incremental increase in concentration of the constituents of regeneration wastes in the Unit 3 discharge and their innocuous nature, adverse effects on organisms in Long Island Sound are not expected. Levels of copper, nickel, and zinc are elevated in the discharge as the result of condenser tube corrosion (Section 5.3.1 above); however, these levels are within the range of values found in Long Island Sound during sampling from 1973-1980 (ER-OL Section 5.3.4). Thus, because of the dilute nature of chemical additions in the Unit 3 effluent discharge and the large volume of water in the quarry available for mixing before discharge into Long Island Sound, the effects of chemical discharge on organisms in Long Island Sound should be minimal.

The concentration of free available oxidant will be limited to 0.1 mg/L at the point of discharge of the service water system to the circulating water system (Sections 4.2.4 and 5.3.1). After mixing with the circulating water and subsequent mixing in the quarry, the amount of residual oxidant at the point of discharge from the quarry to Long Island Sound resulting from operation of Unit 3 should be undetectable (< 0.05 mg/L). Consequently, there should be no effect on aquatic biota from biocide discharge. Because the chemical discharge to the quarry will be dilute (see Section 4.2.6) and further dilution will occur in the quarry before passing to the Sound, there should be no significant synergistic effect of the chemical and thermal discharges on aquatic biota.

Entrainment and Impingement

Planktonic organisms will be entrained in the cooling water withdrawn from Niantic Bay. The entrained organisms will be exposed to a temperature increase of 9.4C° (17F°) upon passage through the condenser. The volume of water withdrawn for Unit 3 operation constitutes approximately 4% of the tidal exchange. Following passage through the Unit 3 cooling system, entrained organisms will be exposed in the quarry to a temperature increase of 10C° to 11C° (18F° to 20F°) for approximately 85 minutes (ER-OL Section 5.1; FES-CP Section 5.3.2). Because operation of Unit 3 will result in twice the volume of water currently discharged to the quarry from Units 1 and 2, the overall temperature in the quarry resulting from the combined discharges of the three units will be decreased.*

Marcy (1973) found that as much as 80% of the mortality from entrainment is the result of mechanical damage (e.g., pressure- and abrasion-induced damage). The extent of mechanical damage varies with plant design, species, size, and developmental stages (Nawrocki, 1977; Suffern, 1977).

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*The temperature increase (12C° to 14C°) and time of exposure (180 minutes) from operation of Units 1 and 2 are greater than those projected for Unit 3 (ER-OL Section 5.1.; FES-CP Section 5.3.2).

Biofouling treatment toxicity can be an important factor in entrainment mortality (Goldman and Quinby, 1979). Because Millstone 3 will use a mechanical cleaning system in the condenser cooling water system, there will be no mortality in the cooling system as the result of chlorination. Discharge from Unit 3 will dilute the residual biocide concentration in the quarry and will reduce the organism exposure time in the quarry by approximately one-half.

Because the volume of water withdrawn by Unit 3 is small relative to that of Niantic Bay, there should be no adverse effect on the phytoplankton or zooplankton population in Niantic Bay. The rapid generation cycle of phytoplankton will compensate for any losses from entrainment. The loss of zooplankton as the result of entrainment will be compensated for by the unaffected zooplankton population.

Estimates of lobster entrainment resulting from the operation of Millstone 3 were based on samples taken during operation of Units 1 and 2. Entrainment ranged from less than 20 to 70 larvae per 24-hour sample, depending on the general population size. Larval lobsters, primarily stage I size, are entrained from May to July. Lobsters produce from 5000 to 115,000 eggs per female (Phillips, Cobb, and George, 1980). At a larval survival rate of 64% (Phillips, et al., 1980), there could be 3200 to 73,600 surviving larvae produced per female during one reproductive period. Assuming 70 larvae per 24 hours are entrained over a 6-week period of susceptibility, approximately 3000 larvae would be entrained. This number is less than the minimum survival rate for larvae produced by one female for one reproductive period. Because of the limited number of larvae entrained in the intake and the short period during which lobster larvae are susceptible (3 to 6 weeks) and subject to entrainment, there should be minimal impact to the lobster population from operation of Unit 3.

Based on operating experience at Units 1 and 2, the finfish taxa entrained in high numbers include anchovies, sand lance, grubby, cunner, tautog, and winter flounder. Eight additional taxa contributed lesser amounts to the estimated entrainment; these are Atlantic menhaden, killifish, silversides, sticklebacks, striped bass, bluefish, scup, and windowpane flounder. Of these 14 taxa, the bluefish, Atlantic menhaden, winter flounder, scup, cunner, tautog, and striped bass are considered important sport or commercial species. From an analysis of life history information (as provided in ER-OL Section 2.2), the lower levels of entrainment for certain taxa are attributable to their preferences for different habitats than presented by the intake area (for example, sticklebacks, killifish, silversides, and windowpane flounder) or to their migratory movements and spawning patterns (for example, bluefish, scup, Atlantic menhaden, and striped bass).

With the addition of Unit 3, the combined three-unit flow rate will approximately double the present two-unit flow rate. Assuming the entrainment losses will also double with three-unit operation increases the potential for population-level impacts on the more susceptible taxa. The applicant has conducted detailed analyses for the 14 taxa using statistical models and population dynamics models for Atlantic menhaden and winter flounder. The applicant's analyses (ER-OL Section 5.1.3.3.4) consider the combined effects of entrainment and impingement losses. Impacts are assessed in terms of adult equivalent losses and comparisons of these projected adult losses with available information on catch-per-unit-effort indices, other historical commercial or sport catch data, and/or the model-generated population projections.

The staff has reviewed the applicant's methods and find them to be state-of-the-art techniques for population-level impact assessments. Results are summarized below for several important finfish species that are most susceptible to entrainment and/or impingement.

Winter flounder have been studied extensively in the Millstone area because they spawn in the Niantic River near the plant site. Adult-equivalent losses were calculated under worst case conditions during operation of the three units. Using 10%, 30%, and 50% egg-to-larvae survival rates (ER-OL Section 5.1.3.3.4.10), the equivalent of approximately 1000 to 10,000 reproductive adult winter flounder would be removed annually. The larger value is equivalent to less than 1% of the 1979 Connecticut recreational catch of 1.3×10^6 winter flounder (Sampson, 1981) and 1.3% of the commercial catch.

According to the FES-CP (Section 5.3.2), the winter flounder larvae that are entrained belong to the group of individuals that are washed from the Niantic Estuary daily. These individuals have a lower natural survival rate than those remaining in the estuary and are, therefore, of less ecological significance than those remaining in the estuary.

Population modeling of winter flounder showed that there is the potential for a 5% to 6% reduction in the total population after 35 years of plant operation (ER-OL Section 5.1.3.3.4.10). Based on population studies and the results of population modeling by the applicant, there will be localized effects on the winter flounder population of Niantic Bay. Because of the source of the larvae (washout from the Niantic Estuary) and probable population compensation, these effects should be minor and should have no significant effect on the winter flounder population of Long Island Sound.

Grubby are the third most abundant fish entrained by operation of Units 1 and 2 (2.4×10^5 estimated equivalent adults, Table 5.6). Larvae constitute most of the entrainment of this species, with an equivalent number of adults entrained ranging from 1.2×10^4 in 1979 to 7.3×10^5 in 1978 (ER-OL Section 5.1.3.3.4.8). The projected adult-equivalent loss from three-unit operation (6.2×10^5, Table 5.6) is within this range. From data presented in the ER-OL (Figure 5.1-12), population levels in the Niantic Bay area and the intake do not appear to have been affected by operation of Units 1 and 2. Although projected entrainment losses are within the observed range of losses from operation of Units 1 and 2, impacts to the grubby population in the vicinity from three-unit operation will be increased. Because the adult-equivalent mortality rate associated with three-unit operation (6.2×10^5) will fall within the mortality range estimated for Units 1 and 2 (range 1.2×10^4 to 7.3×10^5), the overall effect of three-unit operation on the grubby population in Long Island Sound should be of minor consequence.

Cunner ranked fourth in sport fish caught during 1979 (ER-OL Section 2.2.2.5.13). The adult-equivalent loss as the result of entrainment of the pelagic eggs of this species was greater than for any other finfish except anchovies during operation of Units 1 and 2 (Table 5.6). Projected entrainment is expected to increase from 2.2×10^5 to 5.0×10^5 adult equivalents between operation of Units 1 and 2 and operation of Units 1, 2, and 3. This projected increase is expected to be primarily from entrainment of cunner eggs. At an annual population reduction rate of 0.0008 over 40 years of plant operation, the projected reduction in population size would be 3.2% (ER-OL Section 5.1.3.3.4.14); this is a conservative estimate because the Leslie model that the applicant used to calculate these projections does not compensate for entrainment. Cunner are currently considered a trash or nuisance fish (Sampson, 1981) that has increased in abundance in Long Island Sound (ER-OL Section 2.2). Because of their increased population and the ability to compensate for effects on populations, impacts from three-unit operation should be small.

The adult-equivalent projection for entrainment of tautog during three-unit operation is 1.2×10^4 (Table 5.6). Two-thirds of the projected loss is from entrainment of pelagic eggs. The total adult equivalent loss from entrainment is less than 3% of the 1979 recreational catch for Connecticut (Sampson, 1981). From the catch-per-unit-effort data presented in the ER-OL (Figure 5.1-26), it appears that operation of Units 1 and 2 has not had a significant impact on the tautog in the vicinity of the Millstone plant.

In summary, the results of the operational monitoring program show that entrainment effects from operation of Millstone Units 1 and 2 have not had a significant effect on finfish, lobster, or plankton populations in the Niantic Bay area. Entrainment associated with Unit 3 will be minimized to the extent possible by the shoreline intake structure (Section 4.2.4 above). The number of eggs and larvae entrained by three-unit operation is projected to at least double above that entrained during operation of Units 1 and 2. The increase in the numbers entrained will be offset in part by return of impinged organisms from Units 1 and 3 to Niantic Bay (see Section 4.2.4 and the discussion below).

Estimates of the numbers and species of organisms expected to be impinged during operation of the three Millstone units are based on impingement records from Units 1 and 2 for the period from 1976 through 1980. During this period, 98 taxa of fish with a combined annual average of approximately 39,400 individuals have been impinged. Of these taxa, 16 constituted more than 90% of the total fish caught, and 28 taxa constituted more than 95% (ER-OL Section 5.1.3.3.2). Information on numbers of individuals and the percent composition of the predominant fish taxa are presented in Table 5.7.

The number of organisms impinged is expected to vary because of season, time of day, wind velocity, plant operations, and the species present, their size, and their swimming speed. The two seasonal impingement peaks at Millstone probably relate to movement patterns of resident and migratory species. Collections during the winter when water temperatures were less than 5°C (41°F) have been dominated by winter flounder, sticklebacks, silversides, and grubby; the summer samples when water temperature was above 15°C (59°F) were dominated by anchovies and cunner (ER-OL Section 5.1.3.3.2). Impingement occurred with greater frequency at night and after storms. Cooling water flow rates, which are dictated by plant operating conditions, also significantly influenced the numbers impinged (ER-OL Section 5.1.3.3.2). Table 5.7 shows the impingement for Units 1 and 2 and the numbers that are projected to be impinged by operation of Unit 3. With three-unit operation, the impingement rate is projected approximately double. However, fish returns included in the design of Unit 3, and retrofit on Unit 1, should reduce the potential effects of impingement on the local fish population (ER-OL Section 5.1.3.3.2). Studies of impingement mortality for Unit 2 (ER-OL Section 6.1.1.2.2) show that some individuals do survive if they are returned directly to the receiving waters.

Total impingement mortality was calculated for Units 1 and 3 (with fish returns) and for Unit 2 (without a fish return). These totals were then combined for a total impingement mortality estimate (Table 5.8). The results of these calculations show that, with the fish returns at Units 1 and 3, the impingement losses as a result of the operation of all three units will be near or within the range of annual losses for Units 1 and 2. As noted in FES-CP Section 5.3.1, a rubber curtain seaboom was installed at Unit 1 to reduce impingement. However, the seaboom was removed when studies showed that the seaboom acted as an attractant to fish (NUSCo, 1983).

The use of sluiceways to return impinged individuals to Niantic Bay from Units 1 and 3, greater survival than assumed for individuals impinged at Unit 2, and the shoreline intake design of Unit 3 will reduce the overall impact of impingement on fish species in the Niantic Bay area. Because the projected mortality from three-unit operation is generally within the range of values for operation of Units 1 and 2, there should be no increased impingement effect on local fish populations from operation of Unit 3.

Thermal Effects

Phytoplankton appear to be little affected by entrainment (see "Entrainment" discussion above) and should, consequently, be little affected by exposure to the elevated temperature of the thermal plume. Studies conducted for the applicant (see Section 5.1) concluded that a 3.3C° (6F°) temperature increase would extend from the quarry for a distance of only 300 m (1000 feet). Organisms would be entrained in this water for approximately 3 minutes before the water mixed with Sound water, which would further decrease the effluent temperature (ER-OL Section 5.1.3.1). The staff's thermal analysis (Witten, 1984) shows that the change in temperature and the size of the plume would accurately predict the exposure calculated by the applicant.

Zooplankton will be exposed to temperatures in the thermal plume that approach their thermal maxima. Because of the short duration of the time zooplankton are in the thermal plume and their rapid replacement in response to population losses, impacts to zooplankton as the result of three-unit operation should be minimal. Monitoring studies conducted by the applicant (NUSCo, 1982 and 1983) show that (1) decreases in densities of certain species are offset by increases in densities of others and (2) operation of Units 1 and 2 appears to have little effect on the zooplankton community. The rocky subtidal community of approximately 5.6 km (3.5 miles) of shoreline east of Millstone Point during ebb tide and 4.5 km (2.8 miles) surrounding the site during flood tide may be directly affected by thermal discharge from the site (ER-OL Section 5.1.3.2.1). Effects are generally restricted to areas of poor water exchange (Hoagland and Turner, 1980) and should be limited by tidal flushing and exposure for only a limited portion of the tidal cycle. Monitoring during operation of Units 1 and 2 has shown localized effects only in the vicinity of the undiluted thermal effluent (NUSCo, 1982).

Seasonal peaks of flora, algae, and shipworms species may occur as much as 6 months earlier near the effluent than they occur at other sites in the Millstone vicinity (ER-OL Section 5.1.3.2.1). The temperature at the effluent site is 12C° to 14C° (21F° to 25F°) above ambient; this is the only site in the Sound that supports a population of Teredo bartschi, a subtropical species of shipworm.

During three-unit operation, most areas should receive no more thermal addition than they do from operation of Units 1 and 2. Because of the tidal flushing, limited projected thermal increases [0.8C° to 2.2C° (1.5F° to 4F°)], and the annual and (more importantly) the daily temperature fluctuations normally experienced by this community (28C° (50F°) and 4C° (7F°), respectively) (ER-OL Section 5.1.3.2.1), effects on this community from three-unit operation should be limited or even undiscernible.

The intertidal rocky shore and intertidal sand communities are subjected to wide fluctuations in temperature and salinity, both daily and seasonally. Fluctuations in the temperature as the result of the thermal plume should be within the range of temperature fluctuations normally occurring on a daily basis and should affect only those communities in the vicinity of the discharge. Those areas affected by temperature increases generally will be flushed by the subsequent flood tide, which will help minimize impacts to these communities.

The thermal discharge from three-unit operation will be twice that of Units 1 and 2. Because the cross-sectional area of the cut from the quarry to Long Island Sound has been doubled, the area influenced by plume scour at the discharge will be increased. Thermal plume predictions for three-unit operation indicate that the area of the bottom reached by the plume will be small (ER-OL Section 5.1). The increased size of the discharge plume will remove fine sediment, exposing coarse sand and boulders for habitation by inshore lobsters. As long as the discharge temperature remains below 30°C (86°F) [the range is from 11.6°C to 35°C (53°F to 95°F)], this area can be inhabited by adult lobsters (Cooper and Uzman, 1980). Studies during operation of Units 1 and 2 have shown that catch per unit effort was the same in the effluent as in the vicinity of the plant. Larval lobsters are limited to water with temperatures ranging from 10°C to 25°C (50°F to 77°F) (FES-CP Section 5.3.4) and would be adversely affected by the thermal plume above 25°C. Because the temperature of the thermal plume is generally only 2.2C° (4F°) above ambient within 520 m (1700 feet) of the discharge on the flood tide and within 1100 m (3600 feet) on the ebb tide, effects of the thermal plume on larval lobsters should be minimal.

Macroinvertebrates should be little affected by the thermal plume. The plume will extend to the bottom in the area of the discharge and the 2.2C° and 0.8C° (4F° and 1.5F°) isotherms may extend to the subtidal and intertidal areas during a portion of the ebb tide (ER-OL Section 5.3.2.5). Because most benthic species such as the green, rock, and spider crabs are beyond these zones, they should be little affected. The lady and blue crabs, which are active swimming species, may encounter the thermal plume. The blue crab has been attracted to the thermal discharge of power plants and has been collected in effluent temperatures up to 36°C (97°F) in New Jersey (ER-OL Section 5.1.3.2.5); its thermal tolerance has been reported to be 39°C (102°F) for adults and 40°C (104°F) for juveniles (Gift and Westman, 1971).

The Atlantic long-finned squid is found at temperatures of 7°C to ±29°C (45°F to 84°F) and is found most frequently at temperatures from 10°C to 14°C (50°F to 57°F) (Whitaker, 1978 and 1980). The thermal plume may attract squid during the spring and fall; however, the strong discharge currents will probably exclude them, as well as blue crabs, from the warmer waters of the discharge area at the discharge from the quarry to the Sound (ER-OL Section 5.1.3.2.5).

The current of the effluent discharge and the tidal currents of Long Island Sound reduce the temperature increase of the thermal plume from 11.9C° (21.5F°) to approximately 2.2C° (4F°) within approximately 520 m (1700 ft) of the discharge cut. Killifish, sticklebacks, and silversides will be the primary species affected by the thermal plume, because these shore-zone species have upper lethal temperatures of approximately 34°C (93°F), 29°C (84°F), and 32°C (90°F), respectively (ER-OL Section 2.2). Under worst case conditions of a temperature addition of 4C° (6F°) to the shore-zone summer temperature of 33°C (91°F), individuals of killifish, sticklebacks, and silversides unable to avoid the plume would be stressed or possibly killed by these temperature during a portion of the ebb tide. Sand lances, cunner, tautog, and anchovies that could also be affected by this thermal increase all have maximum tolerance temperatures that are less than the ambient summer maximum (31°C (91°F)). Most of these species are capable of sensing the temperature increases and avoiding them. Demersal fish--such as winter flounder, windowpane, and grubby--that live at depths greater than 10 m (30 feet) should not be affected by the thermal plume because of its shallow nature. Fish kills associated with thermal plumes have occurred at Northport, Cape Cod Canal, and Oyster Creek; all the fish kills occurred at temperatures greater than 34°C (93°F) (NRC, 1975).

Operational monitoring of Units 1 and 2 has shown that some fish are attracted to the thermal plume as evidenced by the increased use of the effluent area by sport fishermen. However, no large schools or large catches of sport fish have been reported from the effluent (ER-OL Section 5.1.3.3.1).

Thermal-related fish kills at Millstone to date have occurred only as the result of fish gaining access to the warmer water of the quarry. In 1972, 20,000 to 30,000 Atlantic menhaden were attracted to the warmer water of the quarry and subsequently died. Since that time, a fish barrier has been installed and continuously maintained at the quarry cut. The barrier and the discharge flow [1.4 m^3/s (49 cfs)] should minimize access to the quarry. Approximately 450 stripped mullet and 8 stripped bass were found dead in the quarry in 1978, presumably as the result of decreased water temperature (ER-OL Section 5.1.3.3.1). In 1981, both Units 1 and 2 were shut down during a period when ambient water temperature was decreasing rapidly; temperature in the quarry decreased 18C° (32F°) in 62 hours. As the result of this rapid temperature decrease, approximately 1880 striped mullet, 55 striped bass, 114 white perch, 21 American eel, 2 butterfish, 1 bluefish, and 1 Atlantic tomcod were killed (ER-OL Section 5.1.3.3.1). A new barrier has been installed for operation of Unit 3. Barrier screens will be removed for cleaning when flow through the cut is sufficient to minimize the number of adult fish entering the quarry (ER-OL Section 5.1.3.3.1).

Effects from entrainment of ichthyoplankton in the thermal plume will be minimized by the rapid mixing of the thermal discharge with ambient water in Long Island Sound. Organisms entrained in the plume could be exposed to a temperature increase of 6C° to 11C° (10.8F° to 19.8F°) at the quarry cut to 1.5C° (2.7F°) at the edge of the thermal plume. Because of the limited time these organisms would be exposed in the warmest part of the thermal plume (6°C (10°F) for 3 minutes), the effect from plume entrainment should be minimal. The short time of exposure and small numbers of individuals relative to finfish populations of Long Island Sound should minimize the effects of plume entrainment. The thermal plume discharge as the result of three-unit operation generally will be within the tolerance limits of sand lances, anchovies, grubby, winter flounder, cunner, and tautog. There should be only limited effects on shore-zone organisms as the result of plume entrainment.

5.6 Treatened and Endangered Species

5.6.1 Terrestrial

No populations of the small whorled pogonia (Isotria medeoloides) are known to occur in the areas crossed by the transmission corridor, hence no adverse impacts to this endangered plant are expected.

Two Federally listed endangered species--the peregrine falcon (Falco peregrinus) and the bald eagle (Haliaeetus leucocephalus)--may occur transiently in the area (see Section 4.3.6.1). Raptors are known to collide with power lines occasionally (Kroodsma, 1978), but the low numbers and transient nature of eagles and falcons in the area make such collisions unlikely and unimportant in terms of species mortality. State-listed bird species occurring on site (see Section 4.3.5.1) will, if anything, benefit from the plant because valuable habitat is protected in the wildlife management area.

5.6.2 Aquatic

No threatened or endangered species were identified during preoperational monitoring in the vicinity of the site. The U.S. Fish and Wildlife Service (March 1983) determined that, except for occasional transient individuals, no individuals of species under its jurisdiction are known to exist in the project area.

5.7 Historic and Archeologic Impacts

The staff concludes that the operation and maintenance of Millstone 3 will have no significant impact on sites listed or eligible for listing in the National Register of Historic Places. However, the staff is still investigating the potential for impacts along the transmission corridor. Appendix H contains a letter from the State Historic Preservation Officer (SHPO) stating his opinion that there will be no impact on historical, architectural, and archeological resources as a result of the operation of Millstone 3.

The applicant has provided a Right-of-Way Development and Management Plan for the transmission line to the Connecticut Siting Council and the SHPO for review and comment. The NRC staff will consult with the SHPO in making a final determination.

5.8 Socioeconomic Impacts

The socioeconomic impacts of station operation are analyzed in FES-CP Sections 5.8 and 11.2. Changes that have occurred since that report was issued include an increase in the estimated operating work force to 400 persons and an increase to a maximum of 530 during scheduled refueling outages. The staff does not expect the operating workers or their families to have any significant impact on public or private facilities.

Local purchases of goods and services required for the operation of Millstone 3 were not estimated by the applicant in the ER-OL, but the 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. The applicant estimates that it will have to pay $30 million (1986 dollars) in property taxes annually to the Town of Waterford based on 10-year levelized values and assuming a 14.44% discount factor. The staff anticipates no other significant socioeconomic impacts resulting from the station's operation.

5.9 Radiological Impacts

5.9.1 Regulatory Requirements

Nuclear power reactors in the United States must comply with certain regulatory requirements in order to operate. The permissible levels of radiation in unrestricted areas and of radioactivity in effluents to unrestricted areas are recorded in 10 CFR 20, Standards for Protection Against Radiation. These regulations specify limits on levels of radiation and limits on concentrations of radionuclides in the facility's effluent releases to the air and water (above natural background) under which the reactor must operate. These regulations state that no member of the general public in unrestricted areas shall receive a radiation dose, as a result of facility operation, of more than 0.5 rem in 1 calendar year, or if an individual were continuously present in an area, 2 mrems in any 1 hour or 100 mrems in any 7 consecutive days to the total body. These radiation-dose limits are established to be consistent with considerations of the health and safety of the public.

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 reasonably achievable (ALARA). Appendix I of 10 CFR 50 provides numerical guidance on dose-design objectives for light water reactors (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 a year to the total body or 10 mrems a year to any organ from all pathways of exposure from liquid effluents; 10 mrads a year gamma radiation or 20 mrads a year beta radiation air dose from gaseous effluents near ground level--and/or 5 mrems a year to the total body or 15 mrems a year to the skin from gaseous effluents; and 15 mrems a 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 below 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 EPA 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 Millstone 3, small quantities of radioactivity (fission, corrosion, and activation products) will be released to the environment. As required by NEPA, the 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. Radioactive-waste management systems are incorporated into the plant and are designed to remove most of the fission-product radioactivity that is assumed to leak from the fuel, as well as most of the activation and corrosion-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 areas outside the plant boundaries are to be recorded and published semiannually in the Radioactive Effluent Release Reports for the facility.

Airborne effluents will diffuse in the atmosphere in a fashion determined by the meteorological conditions existing at the time of release and are generally dispersed and diluted by the time they reach unrestricted areas that are open to the public. Similarly, waterborne effluents will be diluted with plant waste water and then further diluted as they mix with the Long Island Sound 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 way 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 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 75% 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 food-chain 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 Millstone 3, 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 that, for example, might be deposited on vegetation, be present in drinking water outside the plant, or be incorporated into cow's 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 Millstone 3 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/she is in the vicinity of the source, or the amount of time the radioactivity inhaled or ingested is retained in his/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 Millstone 3 facility 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 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, shoreline, boating and swimming activities near quarrys or sounds that may be contaminated by effluents, 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 a 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 a year, which is far below natural-background doses, and the doses are subject to substantial uncertainty because of limitations of predictive mathematical models.

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 Pressurized Water Reactors (PWRs)

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 PWRs. Recently licensed 1000-MWe PWRs 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 SERs. 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 270 PWR reactor years of operation is available for those plants operating between 1974 and 1981. (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.) These data indicate that the average reactor annual collective dose at PWRs has been about 500 person-rems, although some plants have experienced annual collective doses averaging as high as about 1400 person-rems a year over their operating lifetime (NUREG-0713, Vol 3). These dose averages are based on widely varying yearly doses at PWRs. For example, for the period mentioned above, annual collective doses for PWRs have ranged from 18 to 3223 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 per quarter, if the average dose over the worker lifetime is being controlled to 5 rems per year, or 1.25 rems per quarter if it is not.

The wide range of annual collective doses experienced at PWRs 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, staff occupational dose estimates for environmental impact purposes for Millstone 3 are based on the assumption that the facility will experience the annual average occupational dose for PWRs to date. Thus the staff has projected that the collective occupational doses for Millstone 3 will be 500 person-rems, but annual collective doses could average as much as 3 times this value over the life of the plant.

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 5.9 to published risks for other occupations. Based on these comparisons, the 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 there may be biological mechanisms that can repair damage caused by radiation at low doses and/or dose rates. 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 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 the Millstone 3 facility is estimated as follows: multiplying the annual plant-worker-population dose (about 500 person-rems) by the somatic risk estimator, the staff estimates that about 0.07 cancer death may occur in the total exposed population. The value of 0.07 cancer death means that the probability of one cancer death over the lifetime of the entire work force as a result of 1 year of facility operation is about 7 chances in 100. The risk of potential genetic disorders attributable to exposure of the work force 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 51.52. 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 51.52, reproduced herein as Table 5.10. 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 PWRs

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. Direct radiation from sources within the plant are due primarily to nitrogen-16, a radionuclide produced in the reactor core. Because the primary coolant of a PWR is contained in a heavily shielded area, dose rates in the vicinity of PWRs are generally undetectable (less than 5 mrems a year).

Low-level radioactivity storage containers outside the plant are estimated to make a dose contribution at the site boundary of less than 1% of that due to the direct radiation from the plant.

Radioactive-Effluent Releases: Air and Water

Limited quantities of radioactive effluents will be released to the atmosphere and to the hydrosphere during normal operations. Plant-specific radioisotope-release rates were developed on the basis of estimates regarding fuel performance and descriptions of the operation of radwaste systems in the applicant's FSAR, and by using the calculative models and parameters described in NUREG-0017.

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 the radioactivated gas 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 interest.

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 strontium 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 and corrosion products, such as nuclides of sodium, iron, and cobalt; 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 rates 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 how 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 Millstone 3 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 a year) or the dose limits (500 mrems a year - total body) specified in 10 CFR 20 as consistent with considerations of the health and safety of the public. As a result, the staff concludes that there will be no measurable radiological impact on any member of the public from routine operation of the Millstone 3 facility.

Operating standards of 40 CFR 190, the EPA 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 NRC staff concludes that under normal operations the Millstone 3 facility is capable of operating within these 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 Millstone 3 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 Millstone 3 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, 24 person-rems) by the preceding somatic risk estimator, the staff estimates that about 0.003 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 death 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, 1978).

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, 24 person-rems), and the estimated dose from occupational exposure (that is, 500 person-rems) by the preceding genetic risk estimators, the staff estimates that about 0.14 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 of the plant (~3.3 million persons in the year 2101) by the current incidence of actual genetic ill health in each generation (~11%), about 1.8 million 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 facility are very small fractions of the estimated normal incidence of cancer fatalities and genetic abnormalities. On the basis of the preceding comparison, the staff concludes that the risk to the public health and safety from exposure to radioactivity associated with the normal operation of the facility will be very small.

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.

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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.

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 Specifications 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 in the Radiological Assessment Branch Technical Position "An Acceptable Radiological Environmental Monitoring Program," Revision 1, November 1979.*

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 in the FES-CP. This early program has been updated and expanded. The operational monitoring program for Millstone Units 1 and 2 serves as a preoperational program for Unit 3 and is summarized in Tables 5.11 and 5.12.

The staff has reviewed the preoperational environmental monitoring plan of the applicant and finds that it is generally acceptable as presented.

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

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 before 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 Millstone 3 facility in accordance with a Statement of Interim Policy published by the Nuclear Regulatory Commission on June 13, 1980 (45 FR 40101-40104). The staff's considerations and conclusions are discussed in the following sections.

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, Section 5.9.4.3 describes actual experience with nuclear power plant accidents and their observed health effects and other societal impacts. This is followed by a summary review in Section 5.9.4.4 of safety features of the Millstone 3 facility 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 within the design bases are then given in Section 5.9.4.5. Also described are the results of calculations for the Millstone 3 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 for being transported into and for creating biological hazards in the environment. Descriptions of these features for Millstone 3 may be found in the applicant's FSAR and in the staff's Safety Evaluation Report (SER, to be published). The most important mitigative features are described in Section 5.9.4.4(1) below.

(1) Fission Product Characteristics

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, some of the assemblies containing these fuel pellets are transferred to a spent-fuel storage pool to create in this storage area the second largest inventory of radioactive material at the plant. 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 gases 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). For this reason 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 hazard, 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. Also, the safety analysis for each nuclear power plant includes assumptions of up to 25% of the core iodine becoming airborne (initially) in the containment. 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 (fallout) or by precipitation (washout or rainout), where they can 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 5.13). 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 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 pathway is the fallout onto open bodies of water of radioactivity initially carried in the air. The second pathway, which is unique to an accident, is created when sufficiently high temperatures inside the reactor core 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; NUREG-75/014), but they have been studied exhaustively in comparison with 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 in this evaluation was based on the 1972 BEIR I Report of the National Academy of Sciences (NAS).

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. 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 April 1984, there were 79 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). (Millstone 3 is designed for 1156 MWe). The combined experience with all these units represents approximately 700 reactor years of operation over an elapsed time of about 23 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 (NUREG/CR-1250). 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 than 100 mrems (NUREG/CR-1250; 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 range of 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 (NUREG/CR-1250; 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 affected.

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 person-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; Thompson and Beckerley, 1964). 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, 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 (Crick and Linsley, 1982). This kind of accident cannot occur in a water-moderated and -cooled reactor like Millstone 3, however.

5.9.4.4 Mitigation of Accident Consequences

Pursuant to the Atomic Energy Act of 1954, the NRC is conducting a safety evaluation of the application to operate Millstone 3. The evaluation will address in detail the safety features of the plant. The principal design features are addressed in the following section.

(1) Design Features

The Millstone station contains features designed to prevent accidental release of radioactive fission products from the fuel and to lessen the consequences should such a release occur. Many of the design and operating specifications of these features are derived from the analysis of postulated events known as design-basis accidents. These accident preventive and mitigative features are collectively referred to as engineered safety features (ESFs). The possibilities or probabilities of failure of these systems are incorporated in the assessments discussed in Section 5.9.4.5.

The steel-lined concrete containment building is a passive mitigating system, which is designed to minimize accidental radioactive releases to the environment. Safety injection systems are incorporated to provide cooling water to the reactor core during an accident to prevent or minimize fuel damage. The containment spray system is designed to spray cool water into the containment to cool the containment atmosphere to subatmospheric pressure within 1 hour after activation of the spray system. The system may also help wash out airborne fission products.

All the mechanical systems mentioned above are supplied with emergency power from onsite diesel generators in the event that normal offsite station power is interrupted.

The fuel-handling building also has accident-mitigating systems. The safety-grade ventilation system contains both charcoal and high-efficiency particulate filters. This ventilation system is also designed to keep the area around the spent-fuel pool below the prevailing barometric pressure during fuel-handling operations so that outleakage will not occur through building openings. If radioactivity were to be released into the building, it would be drawn through the ventilation system and any radioactive iodine and particulate fission products would be removed from the flow stream before exhausting to the outdoor atmosphere.

There are features of the plant that are necessary for its power-generation function that can also play a role in mitigating certain accident consequences. For example, the main condenser, although not classified as an ESF, can act to mitigate the consequences of accidents involving leakage from the primary to the secondary side of the steam generators (such as steam generator tube ruptures). If normal offsite power is maintained, the ability of the plant to send contaminated steam to the condenser instead of releasing it through the safety valves or atmospheric dump valves can significantly reduce the amount of water-soluble radionuclides released to the environment during an accident.

Much more extensive discussions of the safety features and characteristics of the Millstone 3 reactor may be found in the FSAR. The staff evaluation of these features will be in the Millstone 3 SER (to be published). 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. Specifically, the applicant will be required to meet those TMI-2 related requirements specified in NUREG-0737.

(2) Site Feature

The NRC's reactor site criteria, 10 CFR 100, require that for every power reactor the site have certain characteristics that tend to reduce the risk and potential impact of accidents. The discussion that follows briefly describes the Millstone 3 site characteristics and how they meet these requirements.

First, the site has an exclusion area as required by 10 CFR 100. The applicant has defined the exclusion area as equivalent to the area within the site boundary which is identified on Figure 5.5. The exclusion area is owned by two tenants in common: the Connecticut Light and Power Company and Western Massachusetts Electric Company, except for that portion of land designated for the Unit 3 site. The Unit 3 site, which is entirely within the exclusion area, is owned by a number of participants in ownership. Northeast Nuclear Energy Company (NNECO), the operating company and lead applicant for all three units at the Millstone site, has the controlling authority, under contract to the owners, for the exclusion area. The site is traversed from east to west by a ConRail/Amtrak railroad right-of-way. The main line tracks are about 0.72 km (0.45 mile) from the Millstone 3 containment structure. Control of this area is provided for through a written agreement between the applicant and ConRail/Amtrak. A portion of the exclusion area is leased to the Town of Waterford for public recreation and is used primarily for soccer and baseball games. A portion of the exclusion area is located off shore. Control of this area is provided for through a written agreement between the applicant and the U.S. Coast Guard.

Second, beyond and surrounding the exclusion area is a low population zone (LPZ), also required by 10 CFR 100. The applicant has chosen an LPZ radius of 3.8 km (2.4 miles). The LPZ is expected to contain approximately 10,700 persons in 1985 at an average density of 236 persons/km^2 (591 persons/mi^2). By the year 2030, the population is projected to increase to a maximum of 16,000 persons at an average density of 353 persons/km^2 (884 persons/mi^2). Seasonal population variations resulting from an influx of summer residents is minimal. Many of the beaches and recreation facilities in the area are used by residents and do not represent any significant increase in population. 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 Millstone power station. For further details, see 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. Since accidents of greater potential hazards than those commonly postulated as representing an upper limit are conceivable, although highly improbable, it was considered desirable to add the population center distance requirements in 10 CFR 100 to provide for protection against excessive exposure doses to people in large centers. The Town of Waterford, in which Millstone 3 is located, had a 1980 total population of 17,843 (1980 Census). The closest population center to Millstone 3 (that is, a center with more than 25,000 residents, as defined by 10 CFR 100) is the city of New London, which had a 1980 population of 28,842. The distance between Millstone 3 and New London is about 5.3 km (3.3 miles), which is beyond the minimum distance requirements of 5.1 km (3.2 miles) as set by 10 CFR 100.

The safety evaluation of the Millstone site has also included a review of potential external hazards, that is, activities off site that might adversely affect the operation of the plant and cause an accident. This review encompassed nearby industrial, transportation, and military facilities that might create explosive, missile, toxic gas, or similar hazards. The risk to the Millstone 3 facility from such hazards has been found to be negligibly small. Compliance with the Commission's siting criteria for consideration of both natural (for example, earthquakes and floods) and man-made hazards will be discussed in more detail in the staff's SER.

(3) Emergency Preparedness

Emergency preparedness plans including protective action measures for Millstone 3 have been developed by the applicant and, for offsite areas, by state and local authorities. The NRC staff is reviewing the onsite plans, and the Federal Emergency Management Agency (FEMA) is reviewing the offsite plans. 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 plans are provisions for two emergency planning zones (EPZs). A plume exposure pathway EPZ of about 16 km (10 miles) in radius and an ingestion exposure pathway EPZ of about 80 km (50 miles) in radius are required. 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 the actual or potential offsite consequences in the EPZs of a radiological emergency condition.

NRC and FEMA have agreed that FEMA will make a finding and determination as to the adequacy of state and local government emergency response plan. 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 Plan 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 overall and integrated state of preparedness. The NRC staff findings will be reported in its SER.

5.9.4.5 Accident Risk and Impact Assessment

(1) Design-Basis Accidents

As a means of ensuring that certain features of the Millstone 3 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.

The applicant and the staff have considered three categories of accidents. 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 Millstone 3 are shown in Table 5.14. These events are designated design-basis accidents in that specific design and operating features such as those 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 exclusion area boundary, which is about 503 m (1650 feet) distant from the reactor, during the first 2 hours of the accident are also shown in Table 5.14. The results shown in the table reflect the expectation that engineered safety and operating features designed to mitigate the consequences of the postulated accidents would function as intended. An important implication of this expectation is that the releases considered are limited to noble gases and radioiodines and that any other radioactive materials (for example, in particulate form) are not expected to be released. The results are also quasiprobabilistic in nature in the sense that the meteorological dispersion conditions are taken to be neither the best nor the worst for the site, but rather a median value determined by actual site measurements. To contrast the results of these calculations with those using more pessimistic, or conservative, assumptions described below, the doses shown in Table 5.14 are sometimes referred to as "realistic" doses.

The staff has also carried out calculations to estimate the potential upper bounds for individual exposures from the same initiating accidents in Table 5.14 for the purpose of implementing the provisions of 10 CFR 100. For these calculations, much more pessimistic (conservative or worst-case) assumptions are made as to the course taken by the accident and the prevailing conditions. These assumptions include much larger amounts of radioactive material released by the initiating events, additional single failures in equipment, operation of ESFs in a degraded mode,* and poor meteorological dispersion conditions. The results of these calculations taken from the Millstone 3 construction permit SER show that for these events the limiting whole-body exposures are not expected to exceed 11 rems to any individual at the exclusion area boundary. They also show that radioiodine releases have the potential for offsite exposures ranging up to about 83 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 a person jogging for a period of 2 hours. The health risk to an individual receiving such an exposure to the thyroid is the chance of a potential appearance of benign or malignant thyroid nodules of about 3 in 100 cases, and the development of a fatal thyroid cancer in about 10 in 1000 cases.

None of the calculations of the impacts of design-basis accidents described in this section take into consideration 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 as NUREG-75/014, but includes improvements in the assessment methodology that were developed after

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*The containment structure, 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 Millstone 3 ER-OL, Amendment 3, August 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, "Millstone Unit 3 Probabilistic Safety Study" (M-PSS) (letter dated July 27, 1983). The NRC staff contracted with the Brookhaven National Laboratory (BNL) and the Lawrence Livermore National Laboratory (LLNL) to aid in the review of portions of the M-PSS. The results of BNL's review of M-PSS are reported in an informal report submitted by letter dated December 20, 1983. The draft results of LLNL's review of the M-PSS were reported to the staff on May 30, 1984 (Garcia, et al., 1984). The results of the staff analysis of severe accidents are summarized below. Neither the applicant's nor the staff's analyses include the potential effects of sabotage; such an analysis is considered to be beyond the state of the art of probabilistic risk assessment.

Accident sequences initiated by both internal and external causes that are used in the staff analysis are described in Appendix E to this report, and are based on information provided by LLNL and BNL. Accident sequences are grouped into release categories based on 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 M-PSS findings that the hazards resulting from other external events such as tornadoes, transportation accidents, industrial accidents, and turbine missiles do not contribute significantly to the risk from severe accidents. The staff has not completed its analysis of internal and external floods but does not expect these to be significant contributors to risk.

Table 5.15 provides information used in the staff's consequence assessment for each specific release category and summarizes the BNL analysis described in Appendix E. 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

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*However, there are large uncertainties in this analysis in the assessment methodology and the results derived from its application. A discussion of the uncertainties in this analysis 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 Millstone site than those used in the RSS core inventory (see Table 5.13) of seven groups of radionuclides in the release. The radionuclide release fractions shown in Table 5.15 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 E.

The calculated mean value (that is, the point estimate or the best estimate) of probability associated with each release category used in the staff analysis is shown in Table 5.16 (see Appendix E 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 (peak ground acceleration less than 0.5g, that is, Modified Mercalli (MM) intensity scale VIII or lower) (see Appendix E). The second contribution to the probability is ascribed to very severe regional earthquakes as potential causes of reactor accidents, which would also alter offsite conditions adversely to seriously hamper emergency responses that would mitigate the consequences of such accidents. (Appendix J 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 in the data base on (1) failure rates of individual plant components (NUREG/CR-0400) and (2) 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 about 10^{-8} per reactor-year (that is, less than once in 100 million 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 any further discussion of the Table 5.15 accidents and release categories for which the mean probability in Table 5.16 is estimated to be less than 10^{-8} 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 fractions shown in Table 5.15 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 is shown in Table 5.13 for Millstone 3 at a core thermal power level of 3579 MWt. This is the power level used in the applicant's FSAR for analysis of radiological consequences and is used here instead of the 3425 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 nuclides, consideration of the health effects of the nuclides and their 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 of the code are shown in schematic form in Figure 5.6. Environmental parameters specific to the site of Millstone 3 have been used and include

(1) meteorological data for the site representing a full year (1981) 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 5.17)

(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

(4) land-use statistics on a countywide basis within and statewide basis outside an 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 Connecticut, 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 could 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 F) has been revised from that 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 5.18 lists the assumptions and parameters for each emergency response scenario evaluated.

The first set of parameters assumes evacuation of the population within 16 km (10 miles). Although rejected by the applicant as being too conservative, the effective evacuation speed in Table 5.18 is based on an evaluation made by the applicant's contractor, Storch Engineers, in an evacuation study (Appendix 6-3 of M-PSS). The estimate of the delay time before evacuation in the same study was accepted by the applicant in M-PSS and is used in the staff analysis.

The value of delay time in Table 5.18 is consistent with the NRC requirement regarding prompt notification of the public of the emergency and 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, and low to moderately severe earthquakes (up through MM intensity scale VIII). 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 16-km (10-mile) emergency planning zone there normally would be some facilities (such as nursing homes, hospitals, prisons, and schools) where special equipment or personnel might be required to effect evacuation, and there might be some people who would choose not to evacuate. Therefore, actual effectiveness could be greater or less than that characterized by the average values. Because in emergency planning for Millstone special consideration will be given 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 16 km (10 miles), however, the parameters selected reflect the assumption 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); that is, people would relocate. Relocation of the public from the highly contaminated areas beyond 16 km (10 miles) 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 16 km (10 miles) would leave the area (that is, relocate) 6 hours after plume passage. Beyond 16 km (10 miles), relocation 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 m, as opposed to the 16-km (10-mile) 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 5.15 are tabulated in Appendix K. For each release category, separate estimates are provided using each of the offsite emergency response modes in Table 5.18. These conditional mean values are of use only in judging the relative severity of each release category, but 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 Millstone 3 reactor are appropriately weighted by their probabilities.

The consequences and risks** of severe accidents in the Millstone 3 reactor initiated by plant internal causes, fires, and low to moderately severe earthquakes were evaluated using the release categories in Table 5.15, the corresponding probabilities in Table 5.16, and the parameters of the Evac-Reloc mode of offsite emergency response in Table 5.18. 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 5.15, the corresponding probabilities in Table 5.16, and the parameters of the Late Reloc mode of offsite emergency response in Table 5.18. Finally, the overall evaluation of consequences and risks of reactor accidents at Millstone 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.

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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. 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).

**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.

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, 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, and may be used to judge the effectiveness of evacuation and relocation. The staff critique of the principal aspects of the applicant's consequence analysis in the ER-OL, which is identified to be the same as in M-PSS, 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 Millstone 3 and site are presented in the form of probability distributions in Figures 5.7 through 5.11 and are included in the impact summary Table 5.19. The graphs in Figures 5.7 through 5.13 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 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 1 million (1 followed by six zeroes); a probability of 10^{-6} per reactor-year means a chance of 1 in 1 million or one millionth (0.000001) per reactor-year. All release categories shown in Table 5.15 contribute to the results: the consequences from each are weighted by its associated probability (Table 5.16). 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;

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*ry in the plots means reactor-year.

**See 5.9.4.5(7) below for further discussion of areas of uncertainty.

the Late Reloc mode of offsite emergency response was assumed for accidents initiated by very severe earthquakes (see Table 5.18).

Figure 5.7 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 exposure up to 10 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 5.7 may be compared with the annual average dose to the population within 30 km (50 miles) of the Millstone site resulting from natural background radiation of about 370,000 person-rems, and to the anticipated annual population dose to the general public (total U.S.) from normal plant operation of about 70 person-rems (for all units but excluding plant workers) (Appendix D of the environmental statement, Tables D.7 and D.8).

Figure 5.8 represents the statistical relationship between population exposure and the induction of fatal cancers that might appear over a period of many years following exposure for the population within 80 km (50 miles). 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 5.9 shows probability distributions of early fatalities. Two curves are shown representing benefits of two types of medical treatment (supportive and minimal; see Appendix F 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 mostly within 16 km (10 mi) and 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 treatment are predicted to be essentially all within 80 km (50 miles) of the site. As discussed in Appendix F, 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 5.9.

Figure 5.10 shows the probability distributions of early injuries that may result from acute radiation exposure.

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 Millstone is on Long Island Sound, 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 studies of severe accidents at the Indian Point reactors in southeastern New York (Codell, Indian Point Atomic Safety Licensing Board Special Hearing, June 1982-April 1983) and the Limerick reactors in southeastern Pennsylvania (NRC, 1984). In these studies empirical models were developed based on considerations of radionuclide data collected in the New York City and Philadelphia water supply systems as a result of fallout from atmospheric weapons tests. As with the Fermi study, the Indian Point and Limerick evaluations 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 these studies 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, Indian Point, and Limerick. This water pathway would be of small importance compared with 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 the Millstone 3 facility 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 5.11 and are included in the impact summary Table 5.19. 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 5.11 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 1 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 5.12 shows the probability distribution of severely contaminated land area in square meters (about 2.6 million mi^2 equals 1 mi^2) 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 5.12 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 5.19.

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 on the methodology employed in the accident consequence model (NUREG-0340) and do not indicate specific geographical areas.

(5) Release to Groundwater

A groundwater pathway for public radiation exposure and environmental contamination that could be associated with severe reactor accidents was identified in Section 5.9.4.2(2) above. Consideration has been given to the potential environmental impact of this pathway for Millstone 3. The principal contributor to the risk is a core-melt accident in which a penetration of the basemat of the containment building can release molten core debris to the strata beneath the plant. Soluble radionuclides in this debris can be leached and transported with groundwater to downgradient domestic wells used for drinking or to surface water bodies used for drinking water, aquatic food, and recreation. In PWRs, such as that of Millstone 3, there is an additional opportunity for groundwater contamination as a result of the release of contaminated sump water to the ground through a breach in the 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 compared the risk of an accident involving the liquid pathway (drinking water, irrigation, aquatic food, swimming, and shoreline usage) for five conventional, generic, land-based nuclear plants and for a floating nuclear plant, for which the nuclear reactors would be mounted on a barge and moored in a water body. Parameters for the land-based site were chosen to represent averages for a wide range of real sites and are thus "typical," although they do not represent any particular real site. The study concluded that the individual and population doses for the liquid pathway through groundwater contamination range from small fractions to very small fractions of those that can arise from airborne pathways.

The discussion in this section is a summary of an analysis performed to compare the liquid pathway consequences of a postulated core-melt accident at Millstone 3 with that of the generic oceanic land-based site considered in the LPGS. The method consists of a direct scaling of LPGS population doses based on the relative values of key parameters characterizing the LPGS oceanside land-based site and the Millstone 3 site. The parameters that were evaluated include the amounts of radioactive materials entering the ground, groundwater travel time, sorption on geological media, surface water transport, aquatic food consumption, and shoreline usage.

Doses to individuals and populations were calculated in the LPGS without consideration of interdiction methods such as isolating the contaminated groundwater, restricting aquatic food consumption, or prohibiting use of the water. In the event of significant contamination, commercial and sports fishing as well as many other water-related activities could be restricted, if necessary. The consequences would, therefore, be largely economic or social, rather than radiological. In any event, the individual and population doses from the liquid pathway range from fractions to very small fractions of those that can arise from airborne pathways.

All of the reactors considered in the LPGS were Westinghouse PWRs with ice condenser containments. Although there are likely to be differences in the mechanisms and probabilities of release between the LPGS and Millstone 3 reactors, it is unlikely that an actual core-melt liquid pathway release would exceed that conservatively estimated for the LPGS. The source term for Millstone 3 will, therefore, be considered to be equivalent to the LPGS source term.

Groundwater hydrology at the Millstone site is highly complex. Groundwater exists in the bedrock and overlying glacial and recent deposits. In some cases, however, groundwater may be locally confined by a layer of low permeable marine deposits. The water table adjacent to the site is locally recharged by vertical infiltration, especially in areas underlain by permeable geologically deposited ice contact areas or outwash deposits.

Groundwater flow from the site is toward the adjacent coastal waters of Niantic Bay, Jordan Cove, and Long Island Sound and away from any wells; hence, any subsurface release of radioactivity from a core-melt accident will not affect users of groundwater. If no interdictive measures were taken, contaminated groundwater would eventually reach the open water of Niantic Bay and be flushed into Long Island Sound and then to the Atlantic Ocean. The path that the contaminated groundwater would follow is difficult to determine because the intersection between groundwater and surface water in the adjacent bay is indistinct. A conservative estimate of the potential for surface water contamination through the groundwater pathway from a core-melt accident can, however, be made by comparing available information on the Millstone 3 site to the LPGS land-based site.

Preconstruction measurements indicate that the water table beneath the site varies seasonably as well as across the site. The groundwater surface is near plant grade on the northeast side and slopes southwest at the rate of 1 m in 30 m (3 feet in 100 feet). The site has been regraded to a series of benches connected by sloping transitions. Such alterations have affected the site groundwater hydrology, so preconstruction groundwater measurements are no longer valid. No meaningful measurements of groundwater level can be made before major construction operations and site grading are completed. It is possible, however, to predict the general characteristics of groundwater movement to conservatively evaluate the consequences of accidental releases to the groundwater.

The containment building is founded in bedrock at approximately el -12 m (-39 feet) below mean sea level (msl). The top of bedrock varies around the containment building from about mean sea level to el 6.1 m (20 feet) msl. Radioactivity released from a postulated core-melt accident at the Millstone 3 reactor that penetrated the basemat would initially be deposited into the bedrock. The bedrock on the site is a hard crystalline rock consisting of the Monson Gneiss formation and is relatively impermeable.

Part of the precipitation falling on the site will infiltrate the soil and recharge the water table. If infiltration of the precipitation on the site is fairly uniform, the water table would be expected to conform to the general shape of the land surface. Local features such as buildings, site grading, extensive paved areas, and landscaping might influence infiltration, but in general the water table is expected to have its divide in the high ground crossing the area northeast of the reactor site. The location of the divide would mean that the flow of contaminated groundwater from the reactor would be in the direction of Niantic Bay to the southwest. Groundwater could enter bay sediments at the interface of the soil and bedrock, and could travel by way of the structural backfill for the cooling and service water pipelines connecting the intake structure and the power block, or it could seep from places where bedrock is exposed. Although a core-melt release below the basemat would be well within the bedrock, the groundwater pathway resulting in the shortest travel time to surface water would be through the more permeable pipeline backfill. Contaminated groundwater is thus assumed to migrate to the shoreline through the backfilled trenches containing the circulating and service water pipelines and enter the surface water in Niantic Bay. The coefficient of permeability of the structural backfill in the pipeline trenches is taken as the average measured value of 10^{-3} cm/sec. The effective porosity of this soil was determined by porosity tests to be 0.1. The staff has chosen a representative groundwater pathway of 305 m (1000 feet) in length, which is the distance between the center of the Unit 3 containment building and the 1.8-m (6-feet) msl contour adjacent to the intake structure. This contour is above the normal high tide level and is only reached by high tide levels about twice a year. The groundwater level at the site is conservatively chosen to be at plant grade, 7.3 m (24.0 feet) msl, resulting in a conservative estimate of 0.018 for the groundwater gradient.

Using the pathway and parameters discussed above, the travel time for groundwater to migrate to Niantic Bay has been conservatively estimated to be about 5.4 years. It was demonstrated in the LPGS that for holdup times on the order of years, virtually all of the liquid pathway population doses result from Sr-90 and Cs-137. Therefore, the remainder of this analysis considers only these two radionuclides. Movement of much of the radioactivity from an assumed core-melt accident would be slowed by both adsorption and absorption. Retardation factors for Sr-90 and Cs-137 are very difficult to estimate. In NUREG/CR-0912 it is suggested that the distribution coefficients (K_d) for sands, the primary constituent of the backfill, range from 1.7 to 43 for Sr and 22 to 314 for Cs. With the exception of basalts, Cs distribution coefficients are larger, often by an order of magnitude, than those of Sr. For this example, the retardation factors were calculated for a sandy type of soil using conservatively low distribution coefficient values for Sr-90 and Cs-137 of 2 and 20, respectively. This resulted in retardation factors of 28 and 268 for Sr-90 and Cs-137, respectively. This would result in a travel time for Sr-90 and Cs-137 of 148 years and 1438 years, respectively. As a result of radioactive decay, only about 3% of the Sr-90 and virtually none of Cs-137 would eventually enter Long Island Sound. This compares with an estimated 88% of the Sr-90 and 31% of the Cs-137 escaping the groundwater pathway in the LPGS example. The staff has conservatively assumed that any of the Sr-90 or Cs-137 escaping into Niantic Bay would subsequently be carried to Long Island Sound and then to the Atlantic Ocean by tidal currents.

The two major liquid pathways for an ocean-based site are aquatic food consumption and direct shoreline exposure. The commercial and recreational seafood catch (finfish and shellfish) for Connecticut, Rhode Island, and Suffolk County, New York, has been estimated by the applicant to be 53 x 10^6 kg/yr. It was estimated that this catch would be made within a block 200 km along shore and 50 km off shore from the Millstone station. This seafood catch is 3.5 times higher than the approximately 16.6 x 10^6 kg/yr catch for the same size block using the LPGS ocean site parameters.

The applicant has not provided an estimate of the yearly beach usage within 200 km of the Millstone site. Private ownership of extensive sections of the shoreline and limited available beach areas because of the rocky features of the coast limits beach usage. The staff has estimated that beach usage would be about 1 x 10^7 person-hours/yr, or about 50,000 person-hours/linear km/yr. This is 72% of the approximately 1.38 x 10^7 person-hours/yr used in the LPGS site evaluation.

In the case of the LPGS, about 62% of the fish dose and virtually all of the beach dose were due primarily to Cs-137 alone. The remainder of the fish dose was due to Sr-90. About 95% of the population dose was due to fish ingestion, with the remainder being caused by shoreline exposure and swimming.

Combining the ratios of the source term, groundwater pathway, fish catch and shoreline usage indicates that the population dose from a core-melt accident at Millstone 3 would be a factor of 0.03 (or 3%) of that for the LPGS coastal land-based site. The staff, therefore, concludes that the liquid pathway at Millstone 3 does not pose an unusual contribution to risk when compared with other land-based oceanic sites and is small in comparison to the risk posed by airborne pathways.

Finally, there are measures that could be taken to further minimize the impact of the liquid pathway. The staff estimates that the minimum groundwater travel time from the reactor to Niantic Bay is about 5.4 years and that the most significant radionuclides would be retarded by sorption. The travel time would allow time for measures to diminish the migration of the contaminated groundwater off the site. Grouting, where cement or chemical slurrys are injected under high pressure to seal cracks in the rock, and slurry walls, where cement or chemical slurrys are mixed with the in situ soil to form an impermeable barrier, could be used to isolate the contamination. Dewatering of the water table could be used to prevent the mixing of contaminated water from the reactor with groundwater or to collect contaminated water for treatment. A comprehensive discussion of these and other mitigation methods potentially applicable to Millstone is contained in "Accident Mitigation:

Slurry Wall Barriers" (Harris et al., May 1982) and "Accident Mitigation: Alternative Methods for Isolating Contaminated Groundwater" (Harris et al., September 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 5.9.4.5(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.

Table 5.20 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 Millstone 3 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 5×10^{-5} person per reactor-year within 1.6 km (1 mile) of the site exclusion area boundary (EAB) and 1×10^{-2} person per reactor-year within the 80-km (50-mile) region (from Table 5.20) may be compared with such risks from causes other than reactor accidents. Approximately 2000 persons are projected to live within 1.6 km (1 mile) from the EAB and 3.3 million persons are projected to live within the 80-km (50-mile) region in the year 2010. The background cancer mortality rate is 1.9×10^{-3} cancer fatality per person per year in the United States (American Cancer Society, 1981). Therefore, at this rate, about 4 background cancer fatalities per year are expected in the population within 1.6 km (1 mile) of the EAB, and 5200 background cancer fatalities in the population within the 80-km (50-mile) region in the year 2000. Thus, the risk of cancer fatality from reactor accidents at Millstone is small compared with the risk of normal occurrence of such fatality.

The ratio of latent cancer fatality risk from reactor accidents at Millstone 3 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 causes other than reactor accident is 2×10^{-6} ($1 \times 10^{-2}/6000$) 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 2×10^{-4} person per reactor-year with supportive medical treatment and 7×10^{-4} person per reactor-year with minimal medical treatment (from Table 5.20), the staff notes that occurrences of early fatalities with supportive and minimal medical treatment would be contained, approximately, within the 32-km (20-mile) and 80-km (50-mile) regions, respectively. The number of persons projected to live within these regions in the year 2010 is 0.2 million and 3.3 million, respectively. The background risk for the average individual in the United States is 5×10^{-4} accidental death per year (NUREG/CR-1916). Therefore, the expected number of accidental fatalities not related to Millstone 3 per year within the 32-km (20-mile) and 80-km (50-mile) regions is 100 and 2000, respectively, in the year 2010. Thus, the risk of early fatality with supportive or minimal medical treatment from reactor accidents at Millstone is extremely small compared with that from accidents not related to Millstone 3. For an added perspective, the risk of early fatality within 1.6 km (1 mile) of the EAB from reactor accidents may be compared with early fatality risks from nonnuclear accidents in the same region. From Tables L.2 and L.3 in Appendix L, the Millstone risks of early fatality with supportive or minimal medical treatments are 3×10^{-5} person per reactor-year and 8×10^{-5} person per reactor-year, respectively, in this region. At the average rate of 5×10^{-4} nonnuclear accidental death per individual per year in the United States, the number of nonnuclear accidental fatalities in the population of 2010 projected to live within 1.6 km (1 mile) from the EAB in the year 2010 would be 1 per year. This also shows that the early fatality risk from reactor accidents at Millstone is expected to be small compared with the risk of nonnuclear accidental deaths.

The ratio of (1) risk of early fatality with minimal medical treatment from reactor accidents at Millstone 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 8×10^{-5} ($8 \times 10^{-5}/2000 \div 1/2000$) 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 5.18). 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 Millstone 3 accidents are small compared with the background risks from nonnuclear causes.

Figure 5.13 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 with 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 110 mrems/yr from natural background is a virtual certainty for any individual living in the Millstone site region (see Table D.7 in Appendix D).

Figures 5.14 and 5.15, respectively, display risk to an individual of early fatality and early injury, both from early exposure, as functions of distance from Millstone 3 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 Millstone site derived from 1976 meteorological data are shown in Table 5.17. For comparison to early fatality risk to an individual from Millstone 3 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 Millstone 3 accidents, it should be noted that the risk of cancer fatality to an individual in the United States 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 result in the emission of 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, 1983). On the basis of 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.

There are other economic impacts and risks that can be monetized but that are not included in the cost calculations discussed earlier. These impacts, which would result from an accident at the facility, produce added costs to the public (that is, ratepayers, taxpayers, and/or shareholders). These costs would accrue from decontamination and repair or replacement of the facility and from replacement power. Experience with such costs is being accumulated as a result of the accident at Three Mile Island. If an accident were to occur during the first full year of operation of Millstone 3 (1986), the economic penalty associated with the initial year of the unit's operation would be about \$1700 million for decontamination and restoration, including replacement of the damaged nuclear fuel (recovery costs). This estimate is based on a conservative (high) 10% escalation of the \$950 million cost (1980 dollars) estimated for Three Mile Island (Comptroller General, 1981). Although insurance would cover \$300 million or more of the recovery costs, the insurance is not credited against this cost because the $300 million times the risk probability should theoretically balance the insurance premium. In addition, the staff estimates additional fuel costs of $180 million (1986 dollars) for replacement power during each year the Millstone unit is being restored. This estimate assumes conservatively (high cost) that the energy that would have been forthcoming from the unit (assuming 55% capacity factor) will be replaced by oil-fired generation. Assuming the nuclear unit does not operate for 8 years, the total additional replacement power costs would be approximately $1400 million in 1986 dollars.

The probability of a core melt or severe reactor damage is assumed to be as high as 1.8×10^{-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 approximately $3100 million for an accident to the Millstone unit during the initial year of its operation by the above 1.8×10^{-4} probability results in an economic risk of approximately $560,000 in 1986 dollars (or $180,000 in 1980 dollars) applicable to Millstone 3 during its first year of operation. This is also approximately the economic risk (in 1986 dollars) to the Millstone unit 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 unit becomes older, this is conservatively (high cost) considered to be offset by a slightly higher escalation rate than discount rate.

(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 in which uncertainty considerations are important. 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 United States and (2) the unavailability of an acceptably precise and definite procedure to quantify seismically induced accident sequences. In the M-PSS the spectrum of probabilities of seismically induced core-melt sequences varied over a wide range (several orders) of magnitudes. The mean (point or best-estimate) probabilities of seismically induced core-melt sequences used in the staff analysis differ from those of the applicant based on minor requantifications of both the seismic hazard function and mean estimate of fragility. The point estimates of seismic probabilities used to evaluate risks are more representative of Millstone than WASH-1400 values and consider the applicant's estimate of the range of seismic frequency uncertainty. However, point estimates can be vulnerable to the highly judgmental choice of input parameters. 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 interim report published recently ("Seismic Hazard Characterization of the Eastern United States" (SHCP), NUREG/CR-3756) as part of an ongoing study being carried out by Lawrence Livermore National Laboratory (LLNL) for the NRC shows seismic hazard calculations for the Millstone site that are higher than the applicant's by slightly over an order of magnitude. The use of these hazard function calculations means probabilities of seismically induced core-melt sequences significantly greater than those of the applicant. These results are considered preliminary in nature because the SHCP is still in both the feedback and review process.*

Additional studies of seismic hazard calculations in the eastern United States are being carried out by such groups as the Electric Power Research Institute, and there is no reason to believe that these studies or the final hazard results of the SHCP would not show differences in estimated seismic hazard and uncertainty between them and the M-PSS, particularly at the low probabilities. The preliminary SHCP results demonstrate these potential differences. Although the staff believes that only the use of a full range of seismic probabilities in risk analysis would be appropriate, to keep the risk analysis managable, the staff has used only the point estimates of probabilities of seismically induced release categories in the risk analysis and has provided below a general discussion of uncertainty in risk estimates arising from the use of point estimates of probabilities.

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*At this time, the staff does not necessarily believe that one is wrong and the other is right and is attempting to evaluate and determine to what extent this divergence is the result of inherent uncertainties in state-of-the-art hazard estimates, or is from systematic errors in input assumptions.

Inspection of the results shown in Tables L.1a and L.1b and M.1a and M.1b indicates that, with the use of the mean values of probabilities of the release categories initiated by severe earthquakes, these release categories contribute (1) less to the risks of early fatality, (2) about equally to the risk of early injury, and (3) less to the other types of risks--all compared with the risk contributions from the release categories initiated by causes other than severe earthquakes.

Although in the immediate vicinity of the Millstone site (25-km radius) no earthquakes above a magnitude 2.5 have occurred for the past 30 to 40 years, and no historic earthquakes above a magnitude of about 4.5 within 160 km of the site, the staff 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 Millstone 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 5.16 compares the estimate of core-melt probabilities and their uncertainties on the basis of contemporary estimates based on probabilistic risk assessments (PRAs) for several different reactors. Figure 5.16 shows results taken directly from PRAs without modification (Rowsome and Blond, 1982). Figure 5.16 also shows the staff's best estimate of core damage frequency based on the review of the plant-specific probabilistic safety study. The M-PSS did not propagate uncertainties in the overall core damage frequency. Furthermore, 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 that 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 PWR of Surry design (see Appendix E); therefore, the RSS methodology may not have been fully appropriate for the Millstone PWR. Information available in NUREG-0772 indicates that source terms used in the staff analysis cannot be much higher maximally, 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 applicant's PRA would, for example, yield significantly lower estimates of risk than those used by the staff in this report. The NRC staff anticipates better information on source terms at the end of 1984 when the staff's Accident Source Term Program Office and the American Physical Society complete their studies.

- <u>Atmospheric Dispersion Modeling for the Radioactive Plume Transport, Including the Physical and Chemical Behavior of Radionuclides in Particulate Form in the Atmosphere</u>

  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).

- <u>Errors of Completeness, Modeling, Arithmetic, and Omission</u>

  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 Millstone 3, 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:

- <u>Duration and Energy of Release, Warning Time, and Inplant Radionuclide Decay Time</u>

  The assumed release duration, energy of release, and the warning and implant 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 the CRAC code. 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 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 Millstone site may not correspond to what would happen during an actual severe reactor accident. Included in these considerations are 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 2, 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 Millstone 3. 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 Millstone 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 and weathering. 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 5.13 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 on 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 5.13 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 on the uncertainty of the risk estimates. On the basis of the insight gained from the review of similar PRAs for Limerick, Indian Point, and Zion, it is the judgment of the staff that the risk estimates for Millstone 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 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. The various recommendations of these groups and their categorization under the subject areas of Operational Safety, Siting and Design, Emergency Preparedness and Radiation Effects, Practices and Procedures, and NRC Policy, Organization, and Management are compiled in a comprehensive "NRC Action Plan Developed as a Result of the TMI-2 Accident" (NUREG-0660, Vol 1). NUREG-0737, "Clarification of TMI Action Plan Requirements," and Supplement 1 to NUREG-0737 identify 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. Millstone 3 is receiving and will receive the benefit of these actions on the schedule to be discussed in the SER. The improvement in safety from these actions has not been quantified, however.

(8) Comparison of Millstone 3 Risks with Other Plants

To provide a perspective as to how the Millstone 3 reactor compares 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 Millstone 3) are shown in Figures 5.17 through 5.25 for three important categories of risk. The values for individual plants are based on three types of estimates: from the RSS (labeled WASH-1400 Average Plant), from independent staff reviews of contemporary, probabilistic risk assessments (Indian Point Units 2 and 3, Zion, Limerick, and Millstone 3), and from generic applications of accident sequences in the Reactor Safety Study Methodolgy Application Program 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; these estimates appear in Figures 5.17, 5.20 and 5.23 as point estimates along with the corresponding point estimates obtained by the other types of analysis. Figures 5.18, 5.21, and 5.24 show the range of uncertainty that is estimated for those four plants for which a plant-specific probabilistic risk assessment has been performed. Figures 5.19, 5.22, and 5.25 are included to illustrate the effect uncertainties of a factor of 100 would have on comparison among risk estimates using a fixed set of nonplant-specific accident sequences, but site-specific meteorology and population. The display of risk in the 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 5.17 through 5.25 indicate that the estimated Millstone 3 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 5.16, which compares core-melt probabilities for Millstone 3 with several other reactors, indicates that the estimated likelihood of a core-melt accident at Millstone 3 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 Millstone 3. 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). Notable 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, that is, 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 Millstone 3 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 on the methodology developed in the RSS, improvements in 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. Further, the best-estimate calculations show that the risks of potential reactor accidents at Millstone 3 are within the range of such risks from other nuclear power plants. That is, accident risks from Millstone 3 are expected to be a small fraction of the risks the general public incurs from other sources.

On the basis of 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 Millstone 3 site and environs that would warrant consideration of alternatives for Millstone 3.

5.10 Impacts from the Uranium Fuel Cycle

The uranium fuel cycle rule, 10 CFR 51.51 (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," and NUREG-0216, 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." The NRC staff was also directed 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. A proposed 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 5.21 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); that is, the cycle that results in the greater impact is used.

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 Millstone 3 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 purpose of decommissioning is to safely remove nuclear facilities from service and to remove or isolate the associated radioactivity from the environment so that the facility site can be released for other uses. Alternative methods of accomplishing this purpose and the environmental impacts of each method are discussed in NUREG-0586, "Draft Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities."

Since 1960, 68 nuclear reactors--including 5 licensed, low-power reactors--have been or are in the process of being decommissioned. Although no large commercial reactor has undergone decommissioning to date, the broad base of experience gained from smaller facilities is generally relevant to the decommissioning of any type of nuclear facility.

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*The U.S. Supreme Court has upheld the validity of the S-3 rule in Baltimore Gas & Electric Co., et al. v. Natural Resources Defense Council, Inc., No. 82-524, issued June 6, 1983, 51 U.S. Law Week, 4678.

Radiation doses to the public as a result of decommissioning activities at the end of a commercial power reactor's useful life 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 a 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.

Estimates of the economic cost of decommissioning are provided in Section 6 of this report.

5.12 Noise Impacts

Sound pressure levels expected to occur from the operation of Millstone 1, 2, and 3 have been calculated for eight receptor locations. Figure 5.26 provides a sketch of the site area and these eight positions. Receptor positions 1 through 8 also represent the points at which ambient noise measurements were made by the applicant. These measurement locations are representative of the different noise-sensitive areas surrounding the Millstone Station. Of the eight community locations, two each are in Jordan Cove and Pleasure Beach. These two communities have an unobstructed view of the Millstone sites and broadband noise from Units 1 and 2 is generally audible. Three locations were chosen in the Black Point area, and a single location was chosen in the Millstone Road community, where Units 1 and 2 are not generally audible.

Measurements were made during the period of October 16-18, 1979 and again from April 8-11, 1980 (ER-OL Section 5.6.1; response to staff question E290.5). Daytime and nighttime data were acquired at each site during both periods. During each measurement period, data were taken on the octave band spectra and on such statistical indicators as L_{eq},* L_{10}, L_{50}, L_{90},* L_{min}, and L_{max}.

A computer model (Dunn, et al., 1982) based largely on the Edison Electric Institute (EEI) Environmental Noise Guide (Bolt Beranek and Newman, 1978), was used to predict the effect of plant noise at the eight receptors. Calculations were made using the following significant noise sources:

(1) two 630-MVA main transformers for each of the three units

(2) one 40-MVA and one 50-MVA normal station service transformer for each of the three units

Each of these transformers generates tones at frequencies 120, 240, 360, and 480 Hz during its operation.

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*Residual sound levels are represented by the L_{90} percentile level, which is the sound level exceeded 90% of the time. This residual level represents the minimum or background sound level. The equivalent sound level (L_{eq}) is the level of steady noise that would have the same total sound energy as the fluctuating noise actually measured in the community.

The transformers were assumed to be in operation continuously. Standard day conditions (18° C ambient temperature and 70% relative humidity) were also assumed. In the absence of actual noise measurements for these transformers, the data on the noise level of the 40, 50, and 630 MVA transformers were estimated (Gordon et al., 1978). Data on transformers of similar MVA rating were examined, and the staff chose in each case sound power data that represented the strongest source of noise. A conservative assumption was also made in neglecting attenuation resulting from intervening trees between the sources and receptors.

Other noise sources at the site lead to insignificant contributions to community noise levels because of their location inside buildings, their intermittent operation, or their low sound power level. Their contribution to community noise levels also is negligible because of the relatively large distances from these sources to the nearby sensitive areas.

Model predictions indicated that no adverse community reaction should be expected for any of the above receptor locations. The transformers would lead to a slightly audible 360-Hz tone at sites 1, 2, 3, and 5. Predictions indicated that this tone is 1 dB above the masking level at that tonal frequency. Although slightly audible, this tone is very unlikely to lead to annoyance of residents in those areas. Community surveys have shown that the probability of complaints from transformer tones is not significant unless the intruding tonal noise is 5 dB or more above masking level (Anderson and Vér, 1977). Consequently, a lack of significant sources of broadband noise at the Millstone site, as mentioned above, and the very low level of audibility of transformer tones indicate that no adverse community reaction would be expected from operation of the plant.

In the above analysis, conservative assumptions have been made to neglect (1) the noise attenuation due to trees intervening between the transformers and residences, and (2) the effect of partial barriers surrounding the transformer. The additional noise reduction caused by the trees and barriers may be sufficient to lead to the inaudibility of all tones at all noise-sensitive sites.

Two area residents complained about noise from the loudspeakers during construction of Unit 3. These loudspeakers will remain in place and in use during operation of Unit 3. Their residences are in Pleasure Beach (residence A, Site 2) and in the vicinity of Millstone Road and Windward Way in Waterford (residence B). The latter residence is shown on Figure 5.27, which also identifies onsite loudspeakers that would be present during plant operation.

To evaluate the potential for annoyance from these loudspeakers at these two residences, calculations were made for both sites using the closest loudspeaker to each residence. A summary of the calculations performed for residence B is given in Table 5.22. Sound power levels for loudspeaker 761 were estimated from the EEI Evironmental Noise Guide. Attenuation of the sound power as a result of spherical spreading and atmospheric attenuation were included. It is calculated that an increase in noise level of 5 dB would occur in the 500-Hz octave band during loudspeaker operation at residence B. This level is capable of causing annoyance during the period of loudspeaker operation. Noise increments of 5 dB or greater in any octave band have a potential for annoyance (Schultz, 1982). This situation can be easily mitigated by moving loudspeaker 761 toward residence B and reversing the direction of the loudspeaker horn toward the plant.

In this way, the directivity of the loudspeaker (reduction of noise with direction from the main axis) can lead to a minimal noise effect. A second alternative is to replace the loudspeaker with two smaller ones at the same location, each directed opposite from the other and both on a line normal to the present position of the loudspeaker.

Similar calculations were made for the closest loudspeakers to residence A (loudspeaker 950). These calculations show that the loudspeaker during plant operation would be audible at this location at night but would not be sufficiently loud to be annoying. In the 500-Hz octave band, the incremental increase in noise was predicted to be 3 dB (under the 5-dB level estimated for annoyance). Therefore no change to the loudspeaker position or direction is recommended.

These loudspeaker predictions were made using data on loudspeaker sound power levels taken from the literature. These data represent typical loudspeakers that may or may not be representative of the loudspeakers at Millstone. Additionally, response to noise is subjective. If loudspeaker use during station operation causes continual complaints, the mitigative measures discussed for the loudspeaker near residence B may be used for that near residence A. If further mitigation is needed to eliminate annoyance or activity interference, other measures such as sound level reduction or restrictions on the use of these loudspeakers should be investigated.

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 (EOF) for the Millstone Nuclear Power Station on the Millstone site access road is located 2.4 km (1.5 miles) from the plant in Waterford, Connecticut. Because this facility will serve as the EOF for Millstone 3 as it does for the existing two operating Millstone units, no further modifications will be needed and therefore no additional environmental impacts will occur.

5.14 Environmental Monitoring

5.14.1 Terrestrial Monitoring

The FES-CP stipulated that an operational terrestrial monitoring program should be prepared that would be similar to the preoperational program (FES-CP) Section 6.2.3). No program of terrestrial nonradiological operational monitoring has been proposed by the applicant. Because no significant terrestrial impacts are expected from the operation of Millstone 3, the staff now finds that no terrestrial monitoring is needed.

5.14.2 Aquatic Monitoring

5.14.2.1 Water Quality

Water quality monitoring was begun in association with the Millstone Plant in 1968. The program was expanded from 1970 to 1973 to include establishment of baseline chemical water quality. Parameters analyzed on a monthly and quarterly basis are listed in Table 5.23. A 1-year intensive study was conducted in 1974 to determine major seawater constituents and an ongoing program to monitor trace metals in seawater and mollusk tissue was begun in 1971 (ER-OL Section 6.1-1).

The operational monitoring program for effluents from Millstone 3 is included in the NPDES permit (Appendix G) that covers all three Millstone units. The program requirements for Unit 3 are identical to the requirements for Units 1 and 2. Continuous monitoring of the cooling water is required for all three units. The operational monitoring requirements are the same as the preoperational monitoring requirements.

The NPDES permit requires monitoring of the discharge of water used to flush equipment in the primary cooling water system prior to initial plant startup.

5.14.2.2 Ecological

The operational monitoring program will be primarily a continuation of the preoperational monitoring program. The program includes monitoring for entrainment of plankton and fish eggs and larvae, occurrence of fouling and wood-boring organisms, effects on the intertidal community, changes in the local population of lobsters, and effects on shore zone demersal fishes with particular attention to the winter flounder population dynamics.

The plankton study is designed to provide quantitative estimates of the number, seasonality, and types of plankton entrained in the condenser cooling system of Unit 3 concurrently with Units 1 and 2. An off-shore ichthyoplankton survey will be conducted in mid-Niantic Bay for comparison of the number of fish eggs and larvae with the numbers entrained by the Millstone plant. The applicant proposes to modify the operational monitoring program for icthyoplankton to include sampling of the Unit 3 discharge and to change the entrainment sampling from three samples taken 3 days a week to one sample taken 4 days a week. The applicant proposes to count and identify fish eggs only in samples taken from April through September because the number of eggs and the potential impact from entrainment from October through March is very low (ER-OL, Section 6.2.1.1). One day and one night sample from the discharge and mid-Niantic Bay will be analyzed each week for zooplankton.

Two years before Unit 3 operation begins, monitoring of fouling and wood-boring invertebrates will be resumed for two 6-month periods; these data will be compared with operational monitoring samples of fouling and wood-boring organisms. Temporal and spatial differences in the fouling and wood-boring communities have been proposed as indicators of impacts caused by power plant operation (ER-OL Section 6.2.1.3).

Sampling of the intertidal rocky shore area is designed to assess the effects on the intertidal community. The operational monitoring program will be a continuation of the preoperational monitoring program (ER-OL Section 6.2.1.4). The infaunal sand community will be monitored on a quarterly basis at four subtidal and two intertidal stations located in nonimpacted and potentially impacted areas. The sampling and analytical methods will be the same as those of the preoperational monitoring program.

The purpose of the lobster monitoring program is to determine the size of the lobster population, to assess population movement patterns, and to measure population parameters. Data will be compared with preoperational monitoring data to determine if changes are occurring as a result of operation of Unit 3.

Shore-zone and demersal finfish communities will be monitored as part of the operational monitoring program using about the same sampling techniques and program as the preoperational monitoring program (ER-OL Section 6.2.1.7). Shore-zone fish will be monitored using a 9 x 1.2 m beach seine with a 12.7-mm mesh. Three 30-m hauls per station will be taken at each station within the 2-hour period before high tide. Samples will be taken bimonthly except during the winter and early spring months when samples will be taken approximately every 3 months. Demersal fish will be sampled using a 9.2-m Wilcox otter trawl with a 0.6-cm mesh.

The abundance of winter flounder in the Niantic River and Long Island Sound will continue to be monitored using otter trawl catches. Assessment of impact from operation of Unit 3 will be compared with results of operational monitoring associated with Units 1 and 2 to determine if there is a significant increase in effects as the result of the addition of Unit 3 to the Millstone Nuclear Plant system. Mark-recapture studies of winter flounder will be continued to determine population dynamics of flounder, particularly in the Niantic River spawning area.

5.14.3 Atmospheric Monitoring

Onsite meteorological measurements are made on a 142-m tower south of the plant. Measurements of wind speed and wind direction are taken at the 114-m, 43-m, and 10-m levels, and vertical temperature differences are taken between the 114-m and 10-m, and 43-m and 10-m levels. These measurements are available to the control room, the technical support center, and the emergency operations facility through the plant safety parameter display system (SPDS). These measurements will continue during plant operation.

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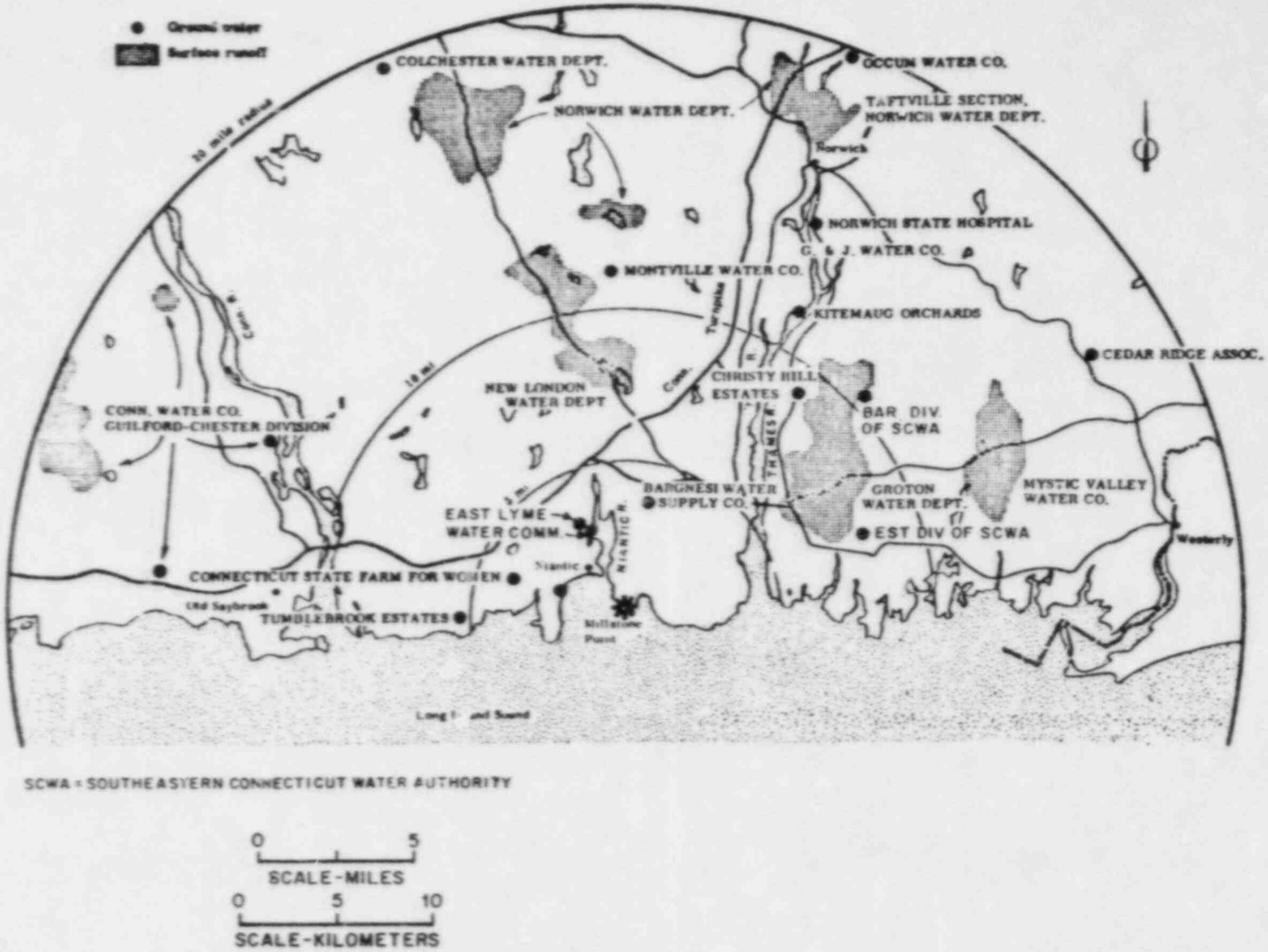


Figure 5.1 Public water supplies within 32 km of the site

SOURCE: CONN. STATE HEALTH DEPT. DIVISION OF SANITARY ENGINEERING BUREAU & ENVIRONMENTAL HEALTH SERVICES DIVISION

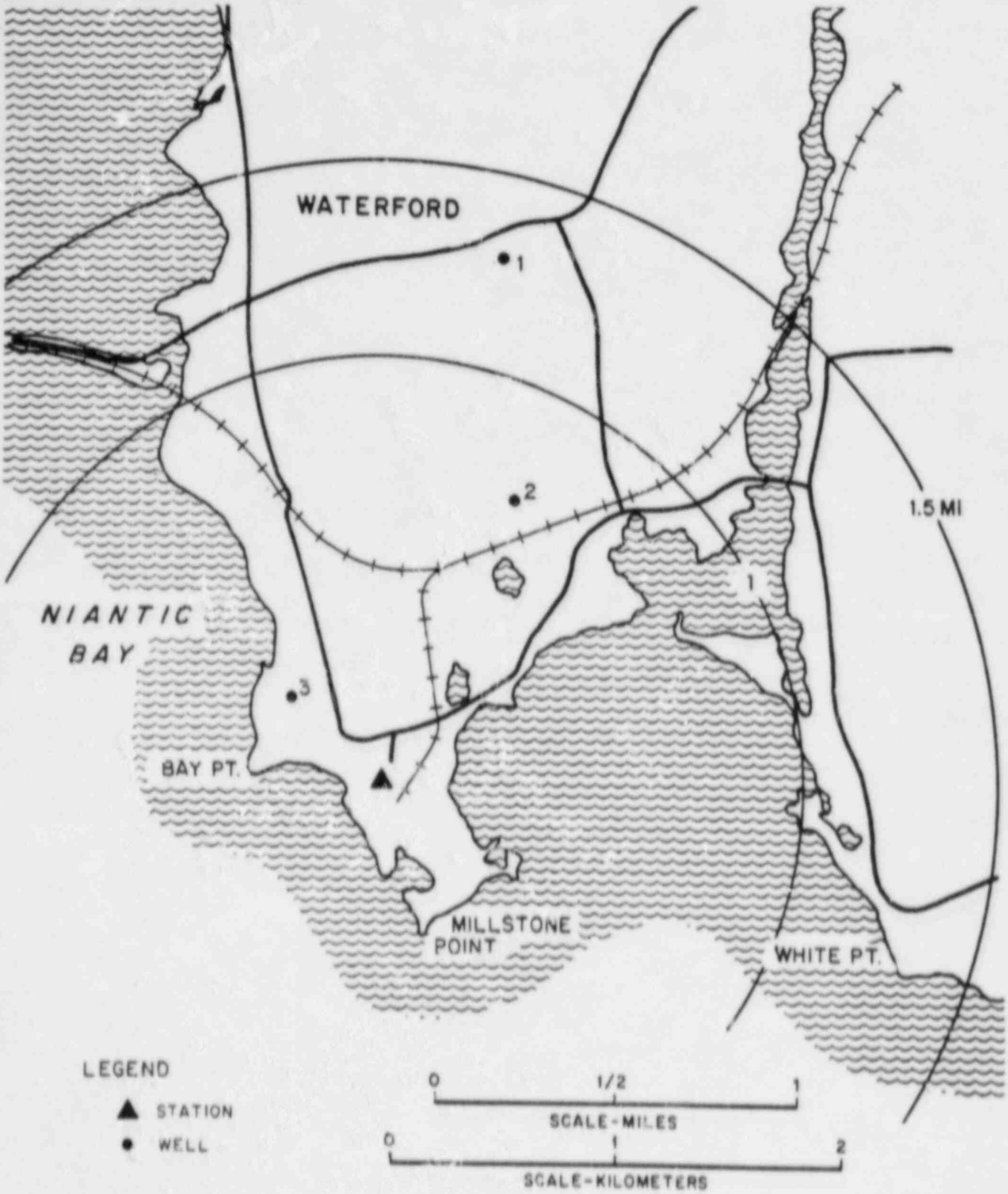


Figure 5.2 Onsite well locations

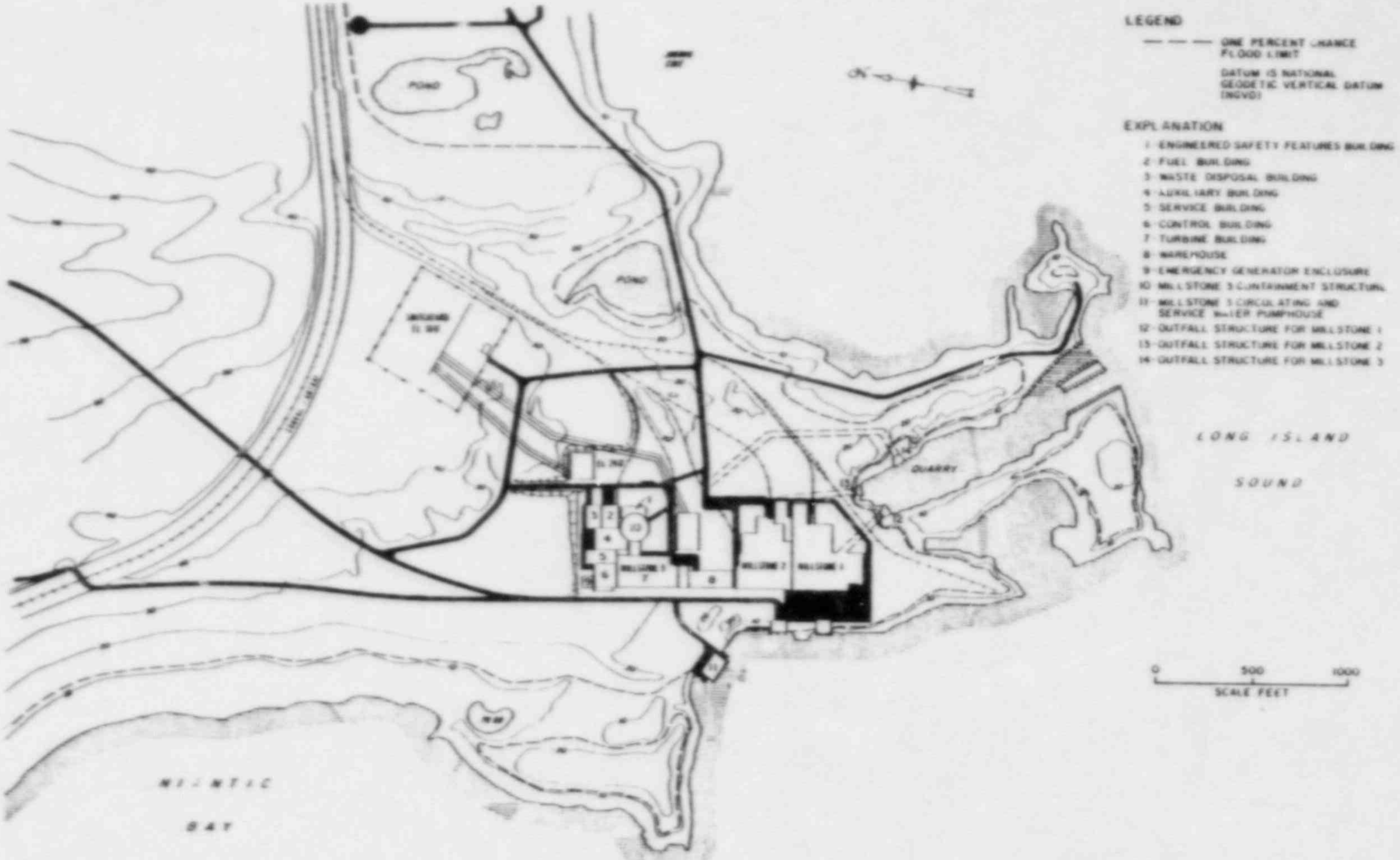


Figure 5.3 1% chance flood limit in the vicinity of Millstone 3 after plant construction

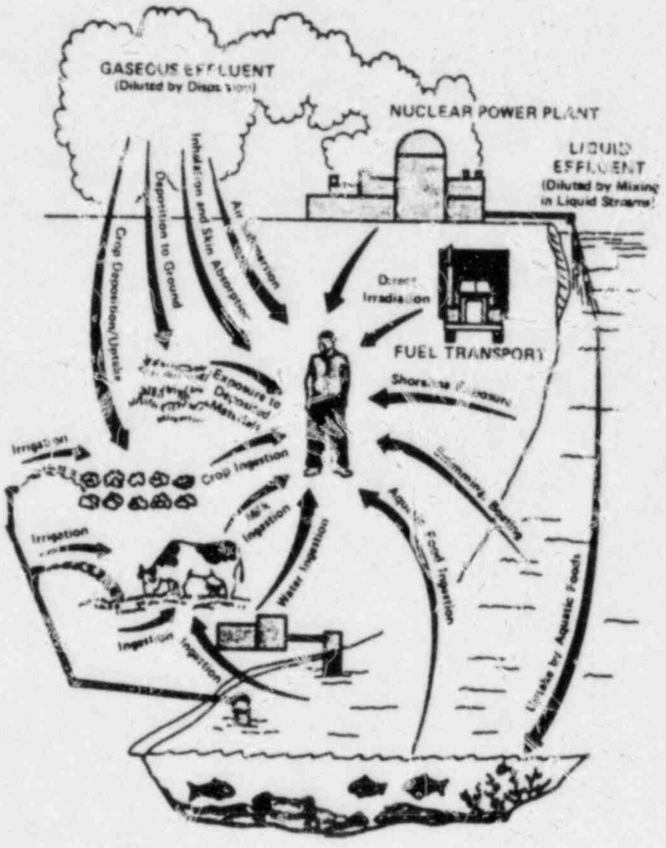
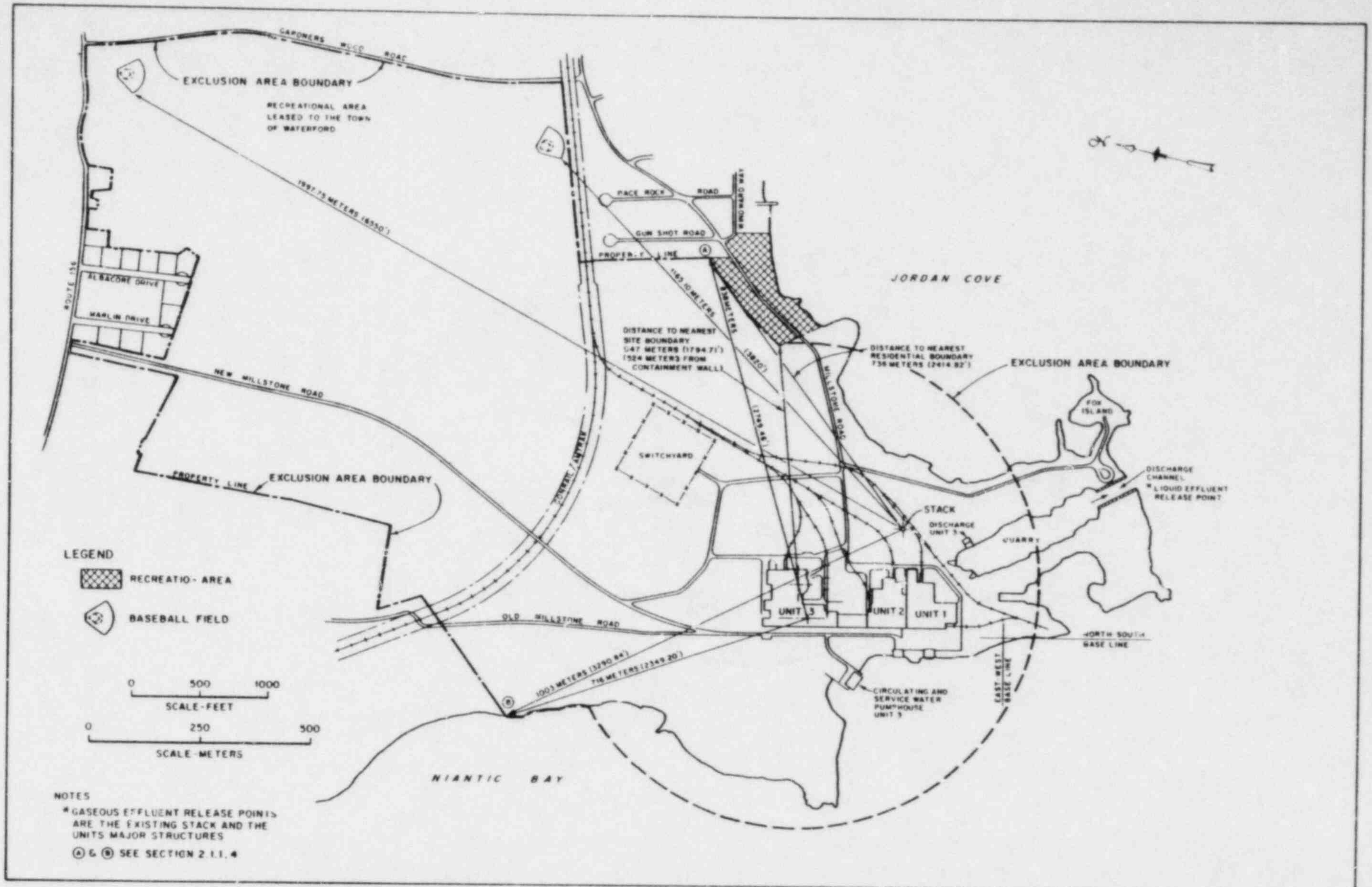


Figure 5.4 Potentially meaningful exposure pathways to individuals



NOTES

* GASEOUS EFFLUENT RELEASE POINTS ARE THE EXISTING STACK AND THE UNITS MAJOR STRUCTURES

Ⓐ & Ⓑ SEE SECTION 2.1.1.4

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Figure 5.5 Site layout--Millstone Nuclear Power Station Unit 3
Source: ER-OL Figure 2.1-3

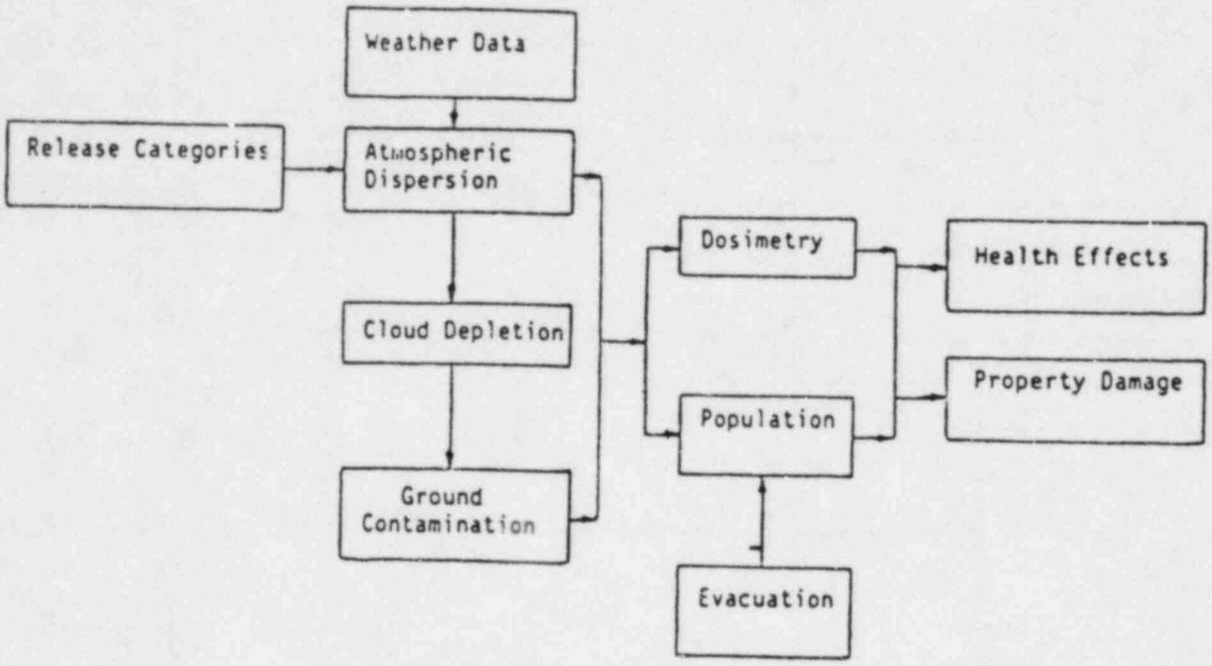


Figure 5.6 Schematic outline of consequence model

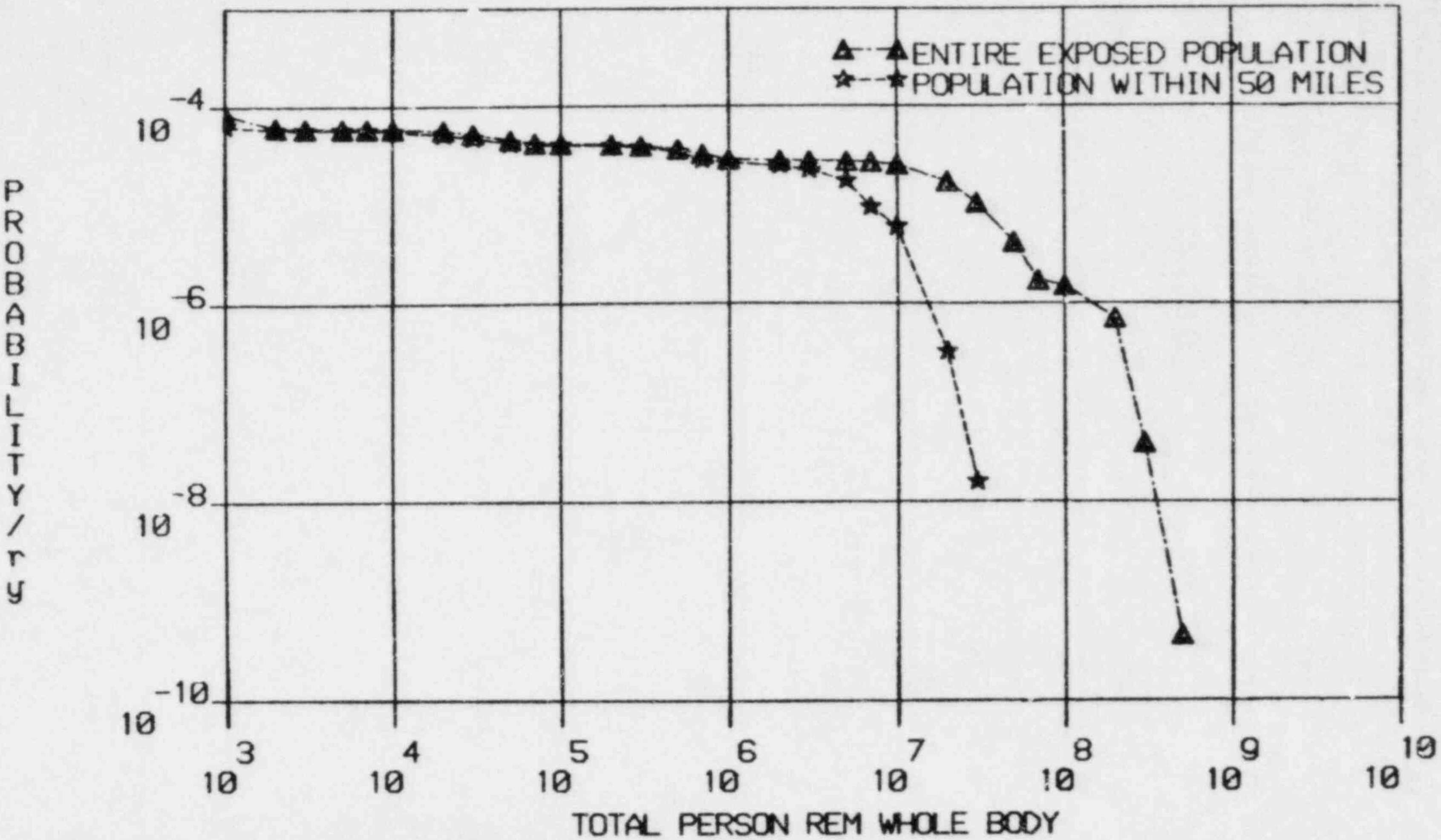


Figure 5.7 Probability distributions of population exposures

NOTES: (1) The average annual dose to the population within 50 miles resulting from natural background radiation is about 370,000 person-rems.

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

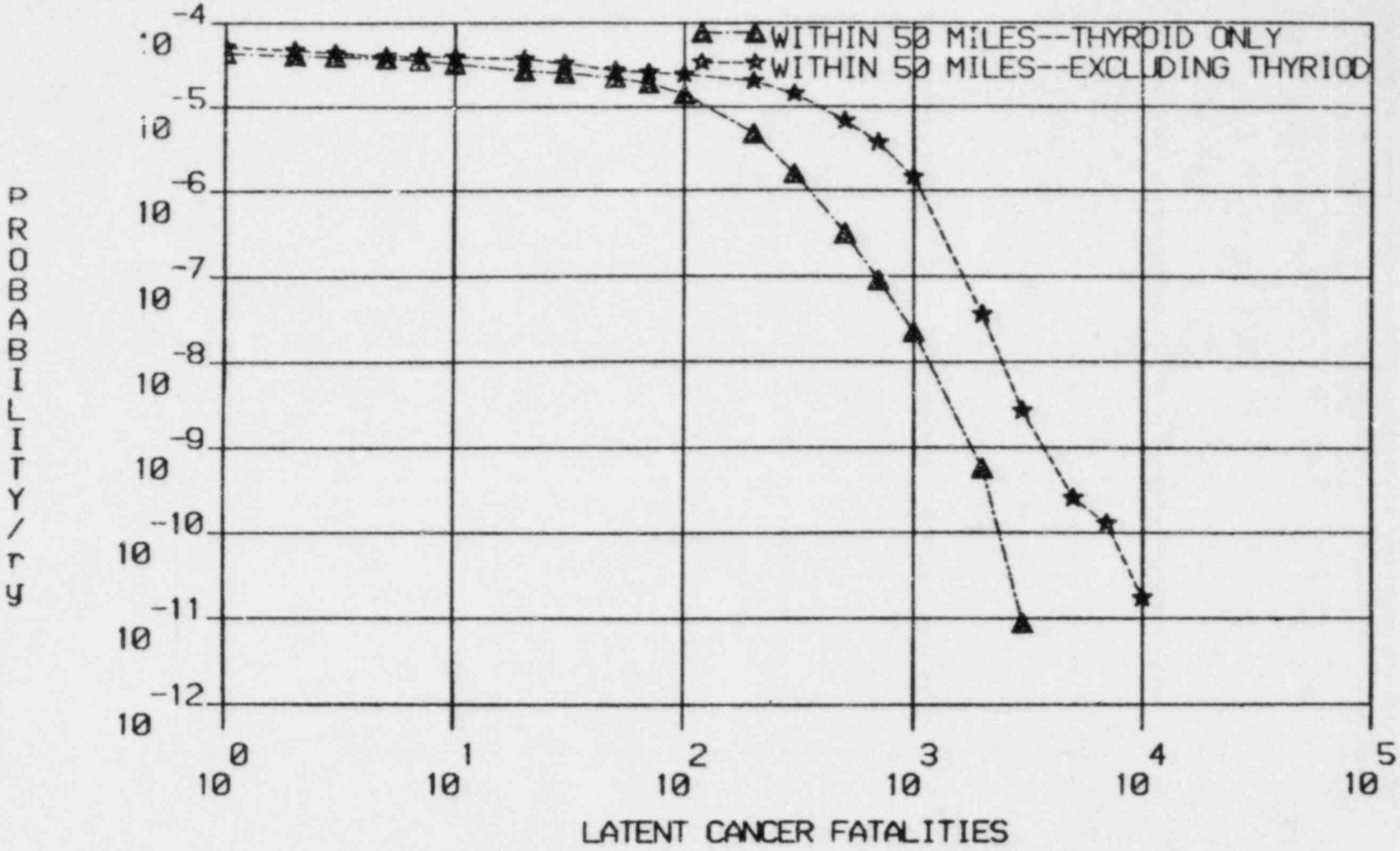


Figure 5.8 Probability distributions of cancer fatalities
NOTE: See Section 5.9.4.5(7) for a discussion of uncertainties.

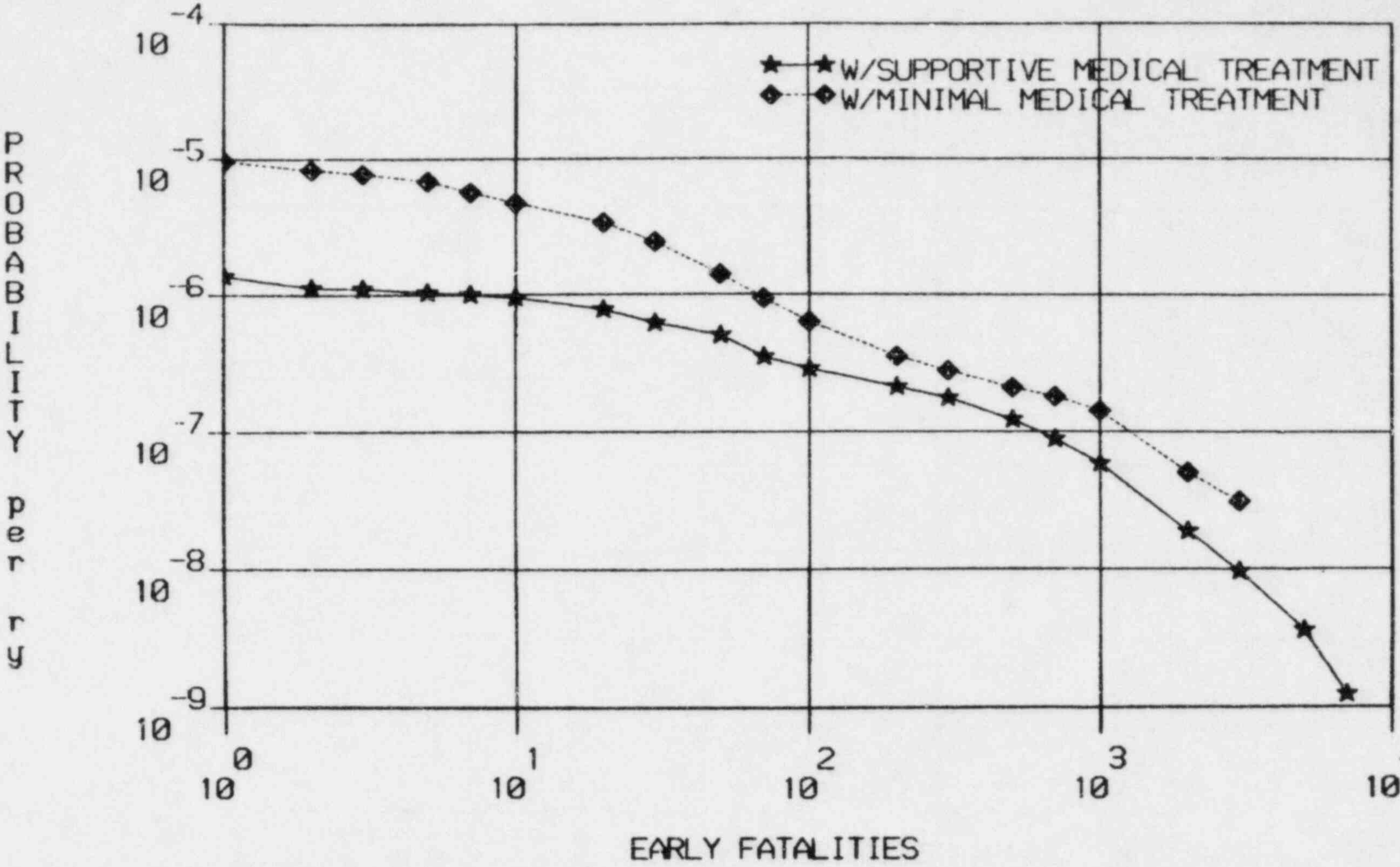


Figure 5.9 Probability distributions of early fatalities
NOTE: See Section 5.9.4.5(7) for a discussion of uncertainties.

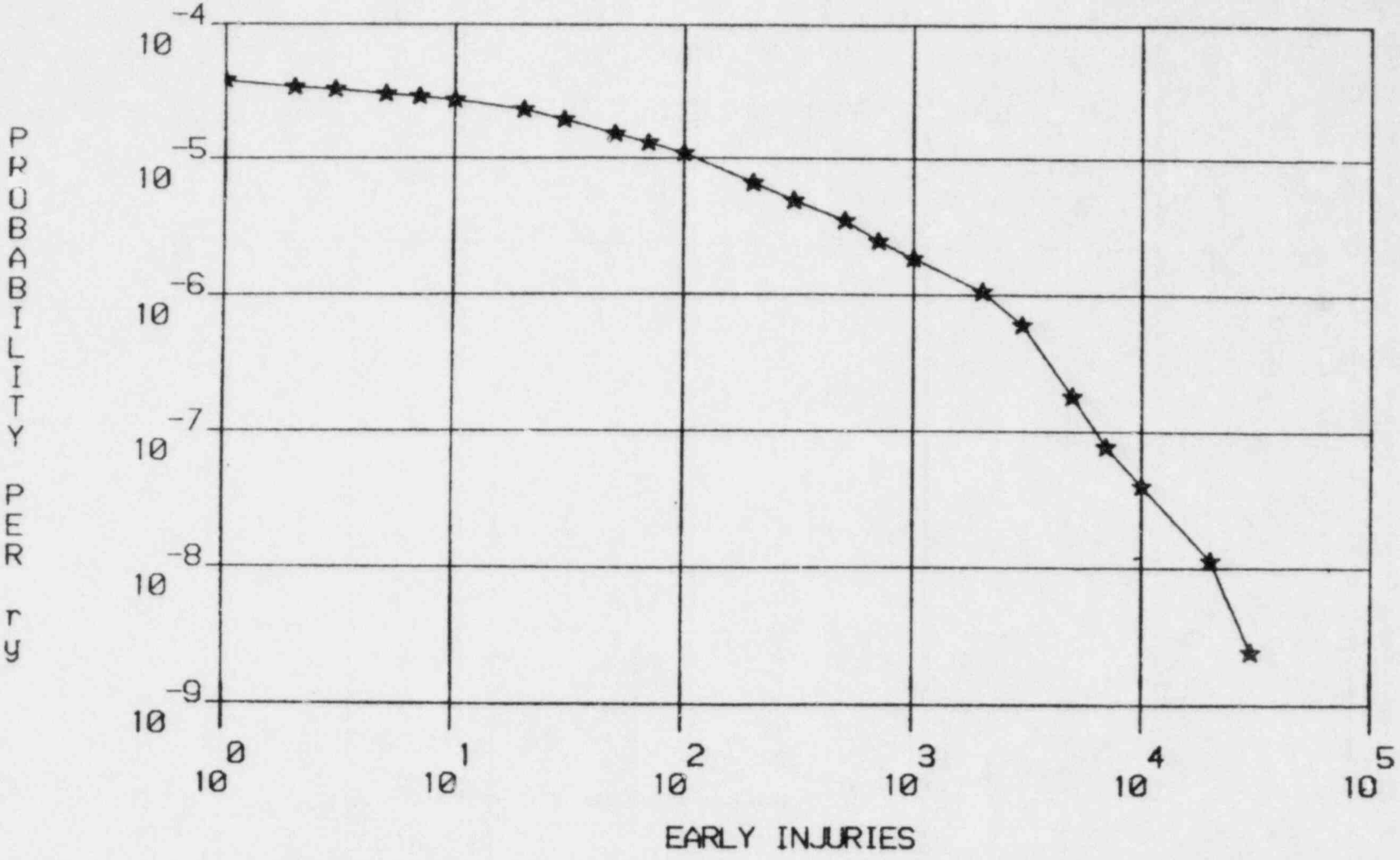


Figure 5.10 Probability distribution of early injuries
NOTE: See Section 5.9.4.5(7) for a discussion of uncertainties.

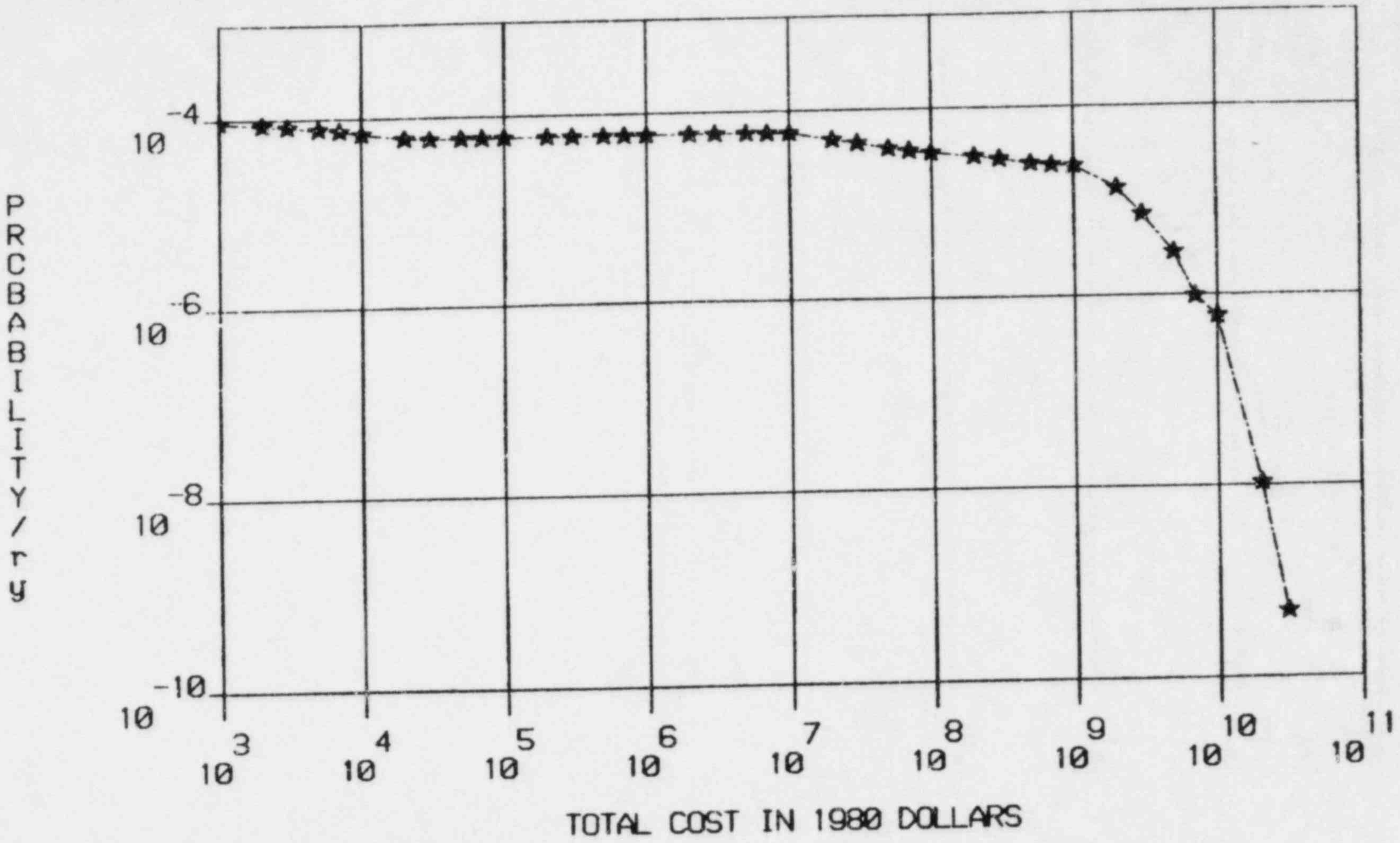


Figure 5.11 Probability distribution of cost of mitigation measures
NOTE: See Section 5.9.5(7) for a discussion of uncertainties.

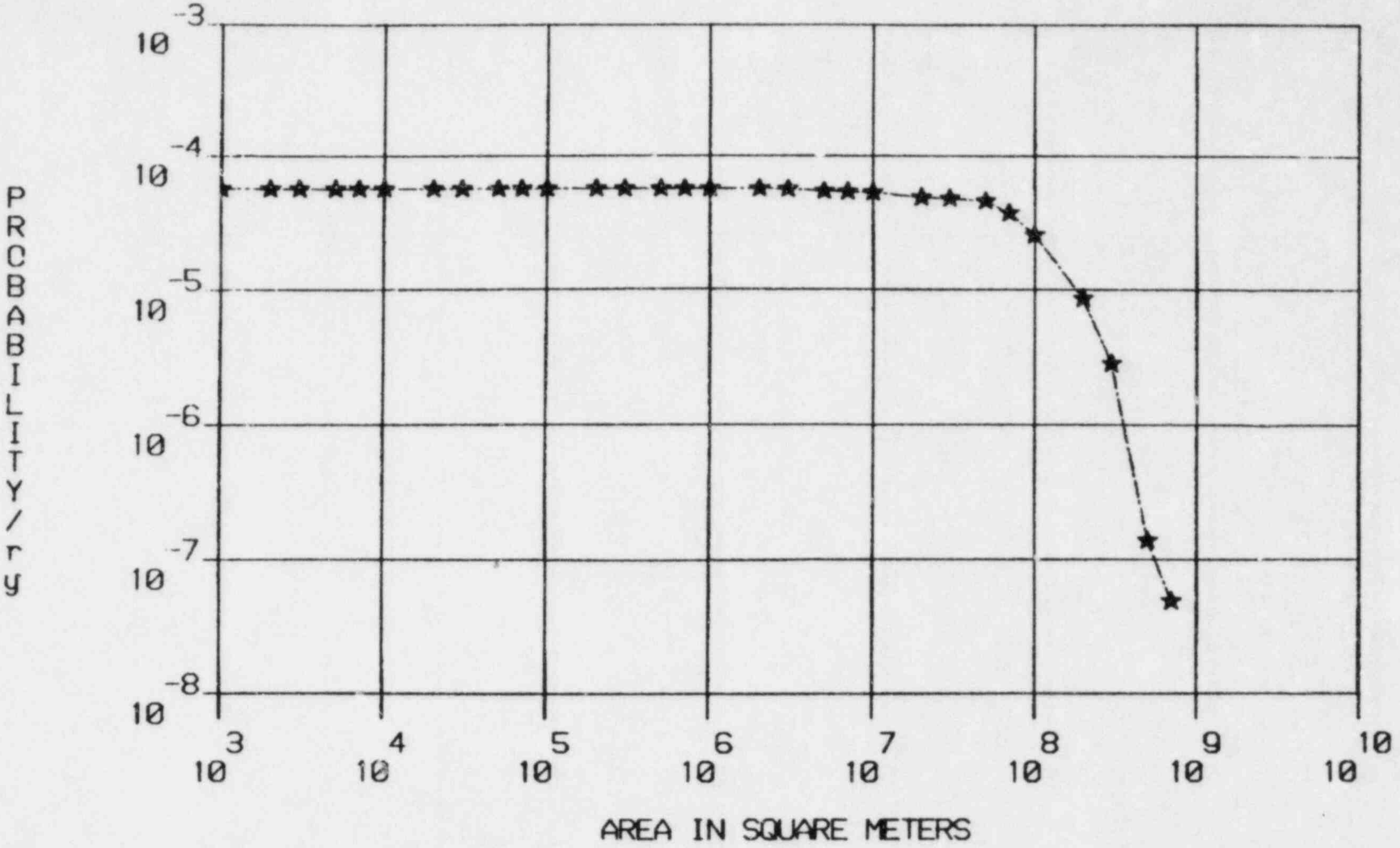


Figure 5.12 Probability distribution of land area interdiction
NOTE: See Section 5.9.4.5(7) for discussion of uncertainties.

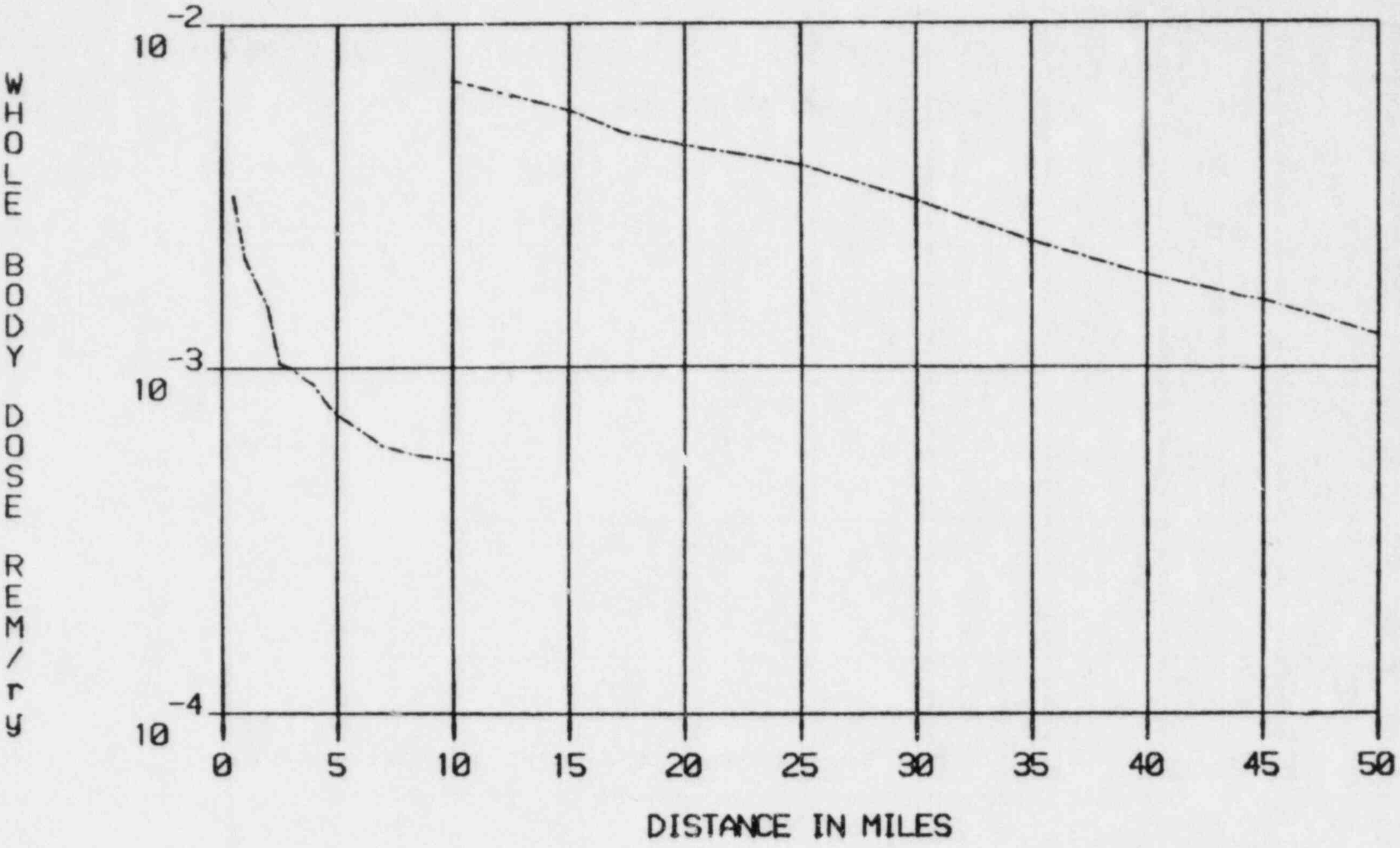


Figure 5.13 Risk of downwind individual dose versus distance
NOTE: See Section 5.9.4.5(7) for discussion of uncertainties.

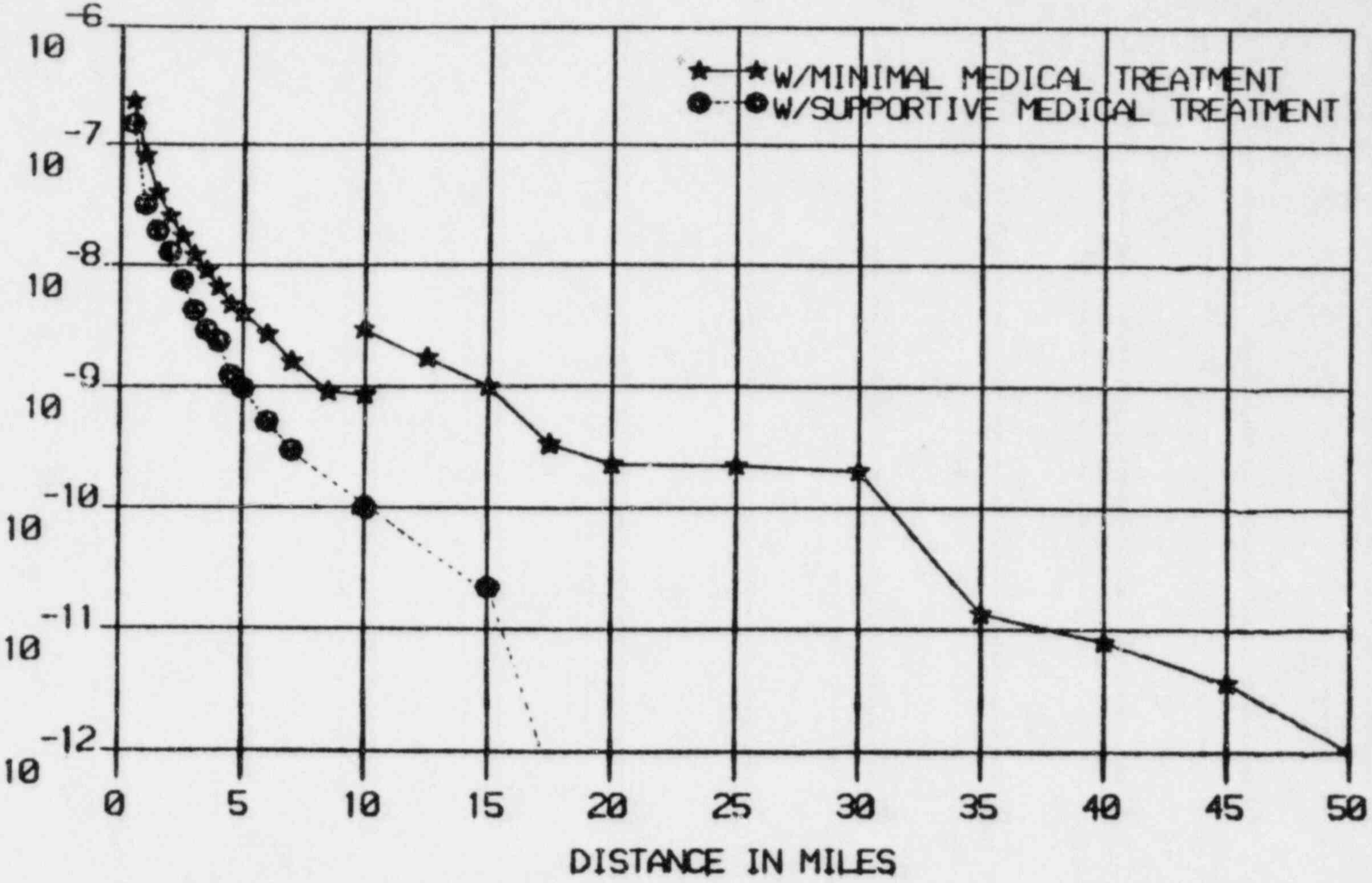


Figure 5.14 Individual risk of early fatality versus distance
NOTE: See Section 5.9.4.5(7) for discussion of uncertainties.

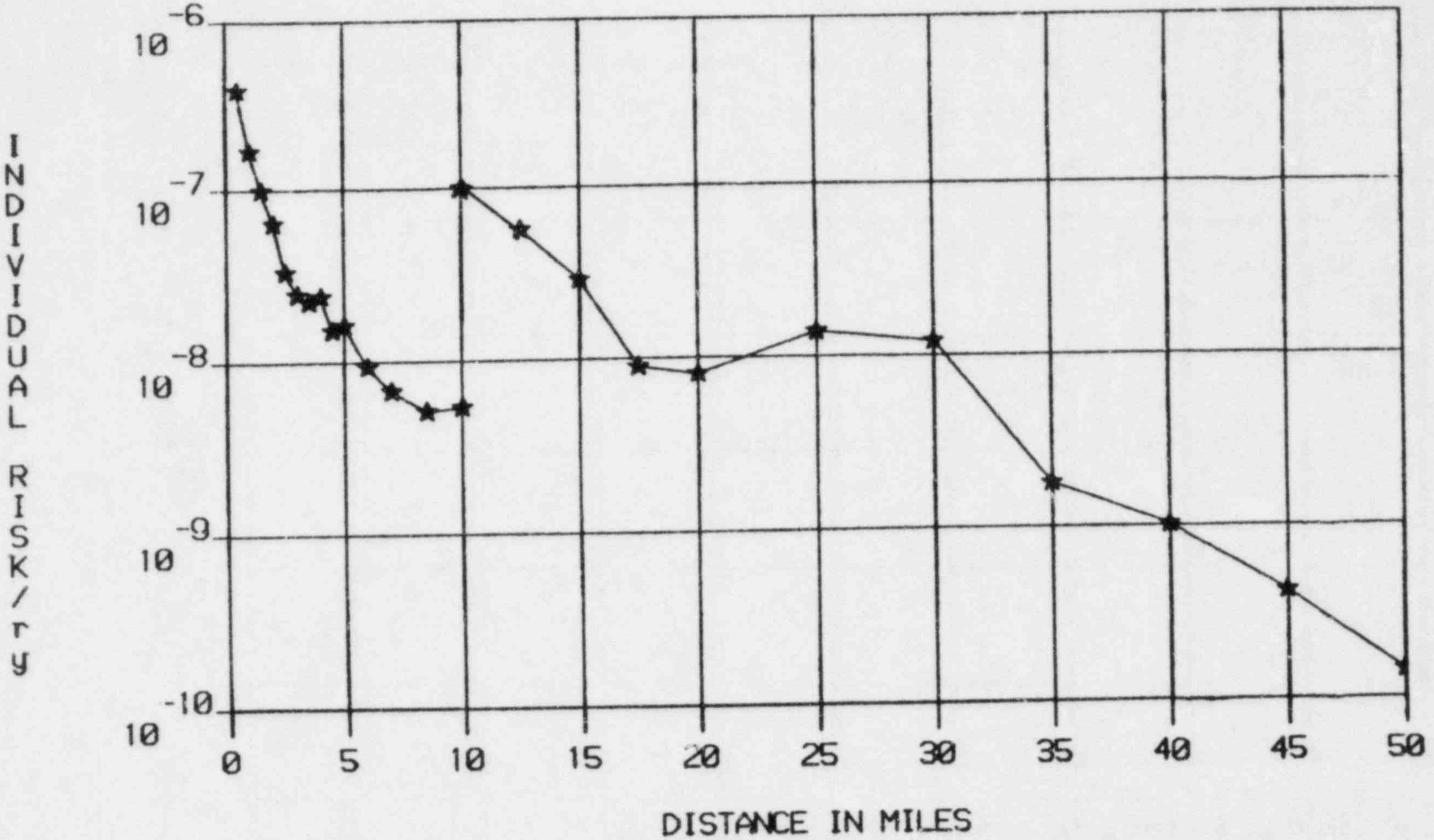
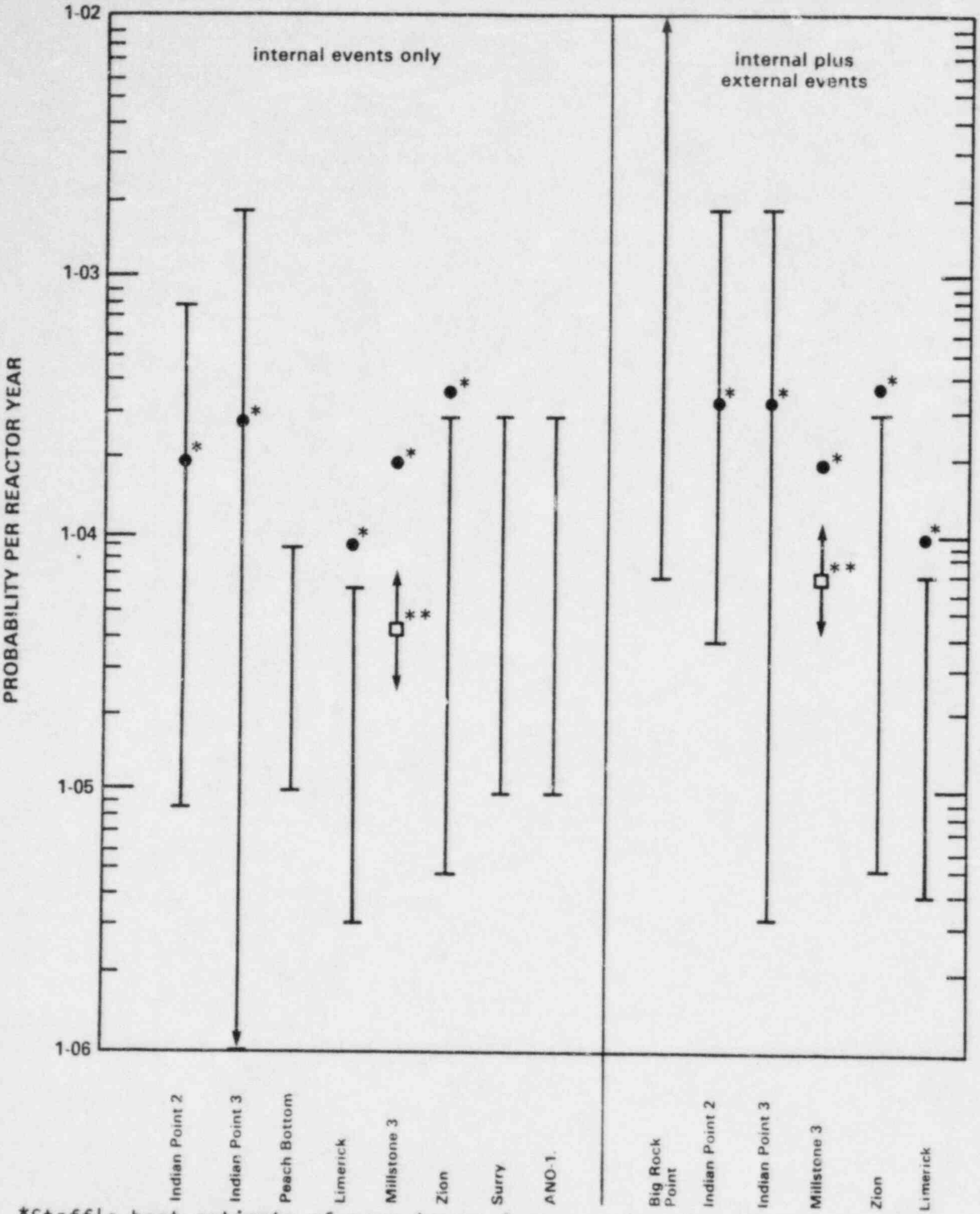


Figure 5.15 Individual risk of early injury versus distance
NOTE: See Section 5.9.4.5(7) for discussion of uncertainties.



*Staff's best estimate of core damage frequency based on the review of the plant-specific probabilistic safety study. For discussion of uncertainties see Section 5.9.4.5(7).

**Northeast Utilities (NE) mean estimate of core damage frequency. NE did not propagate uncertainties in the overall core damage frequency.

Figure 5.16 Core-melt probability uncertainty bounds for internal events and internal plus external events based on results taken directly from published PRAs

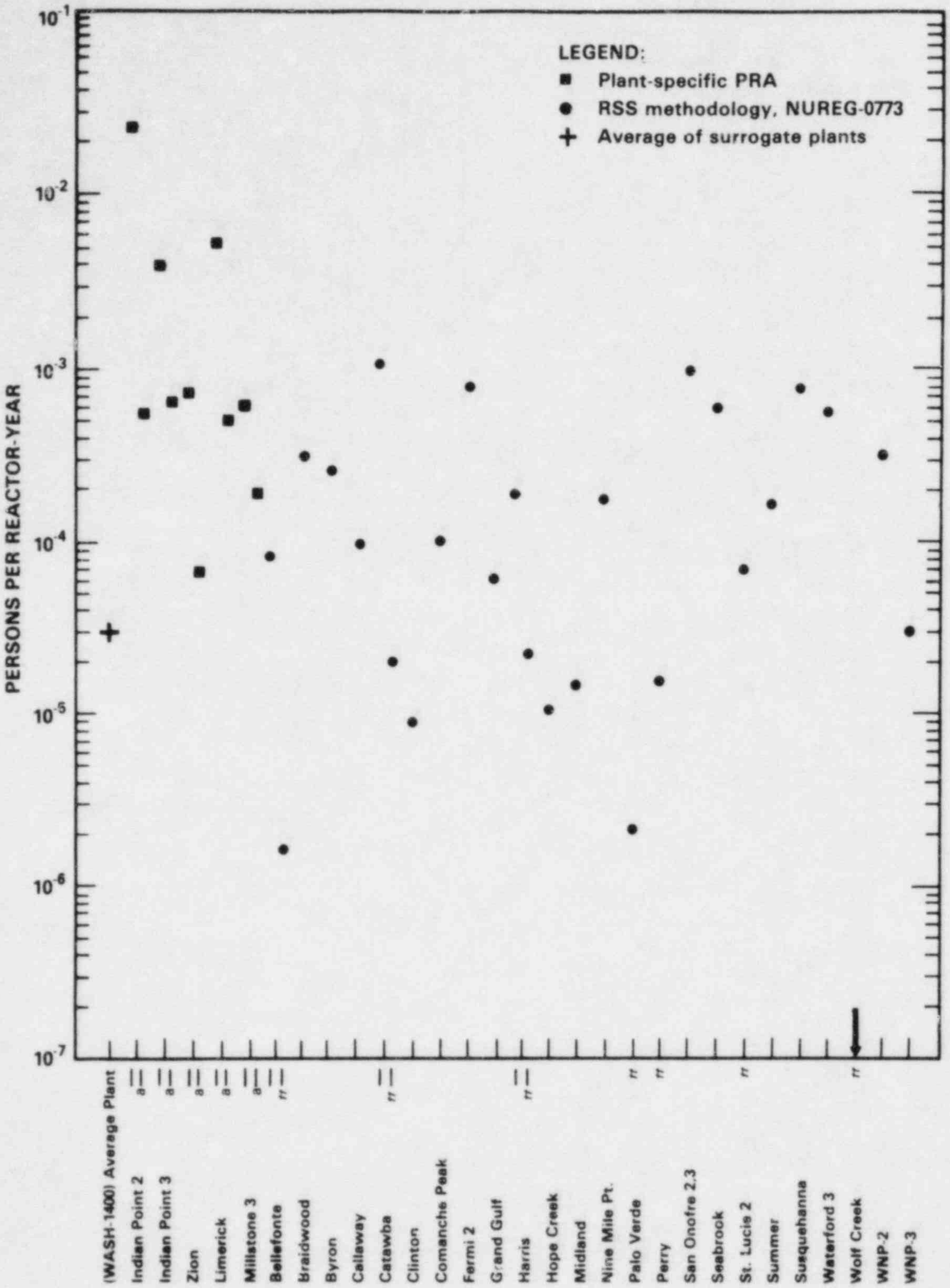


Figure 5.17 Estimated early fatality risk with supportive medical treatment (persons) from severe reactor accidents for several nuclear power plants either operating or receiving consideration for issuance of license to operate. See footnotes following Figure 5.25.

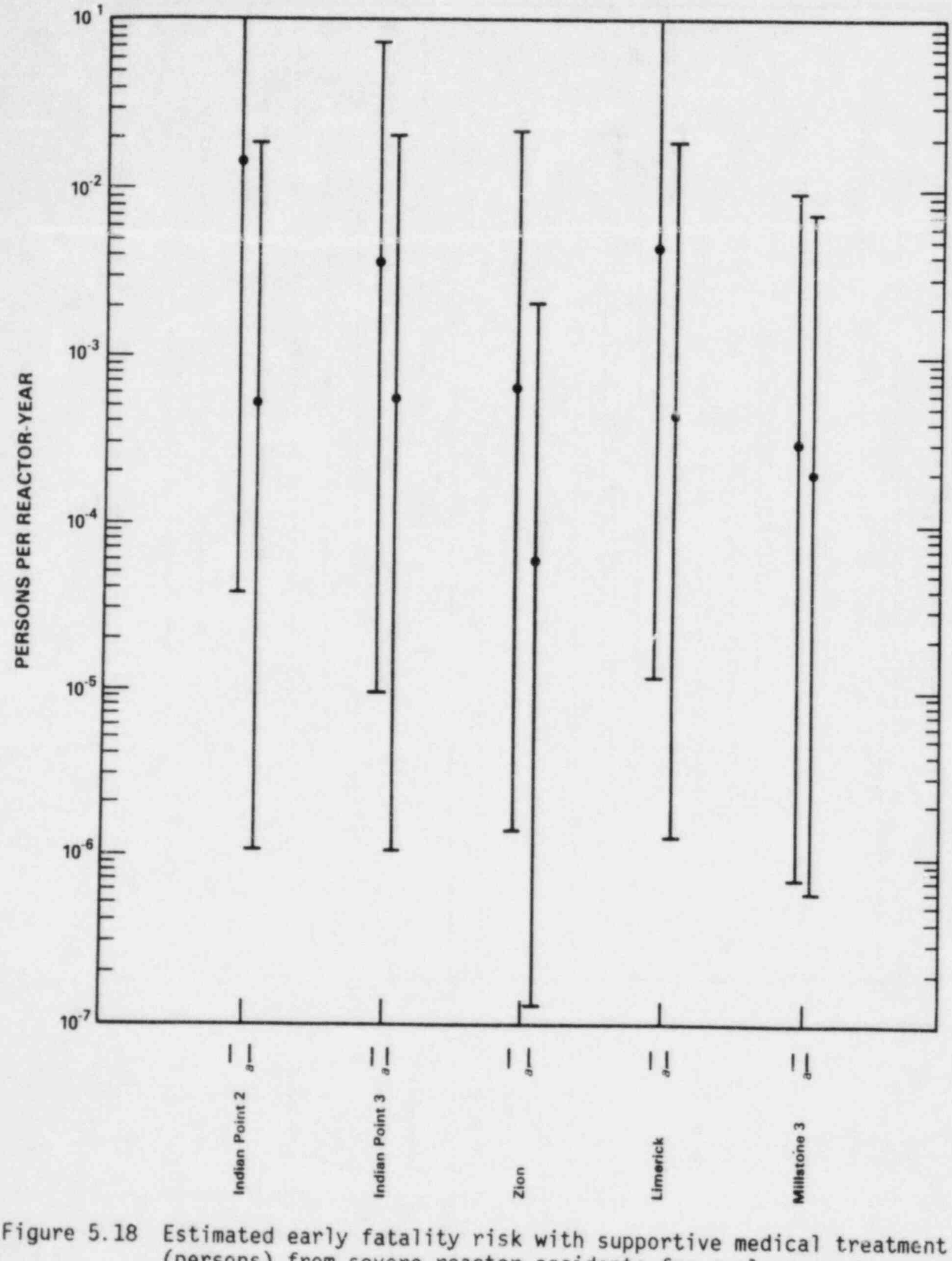


Figure 5.18 Estimated early fatality risk with supportive medical treatment (persons) from severe reactor accidents for nuclear power plants having plant-specific PRAs, showing estimated range of uncertainties. See footnotes following Figure 5.25.

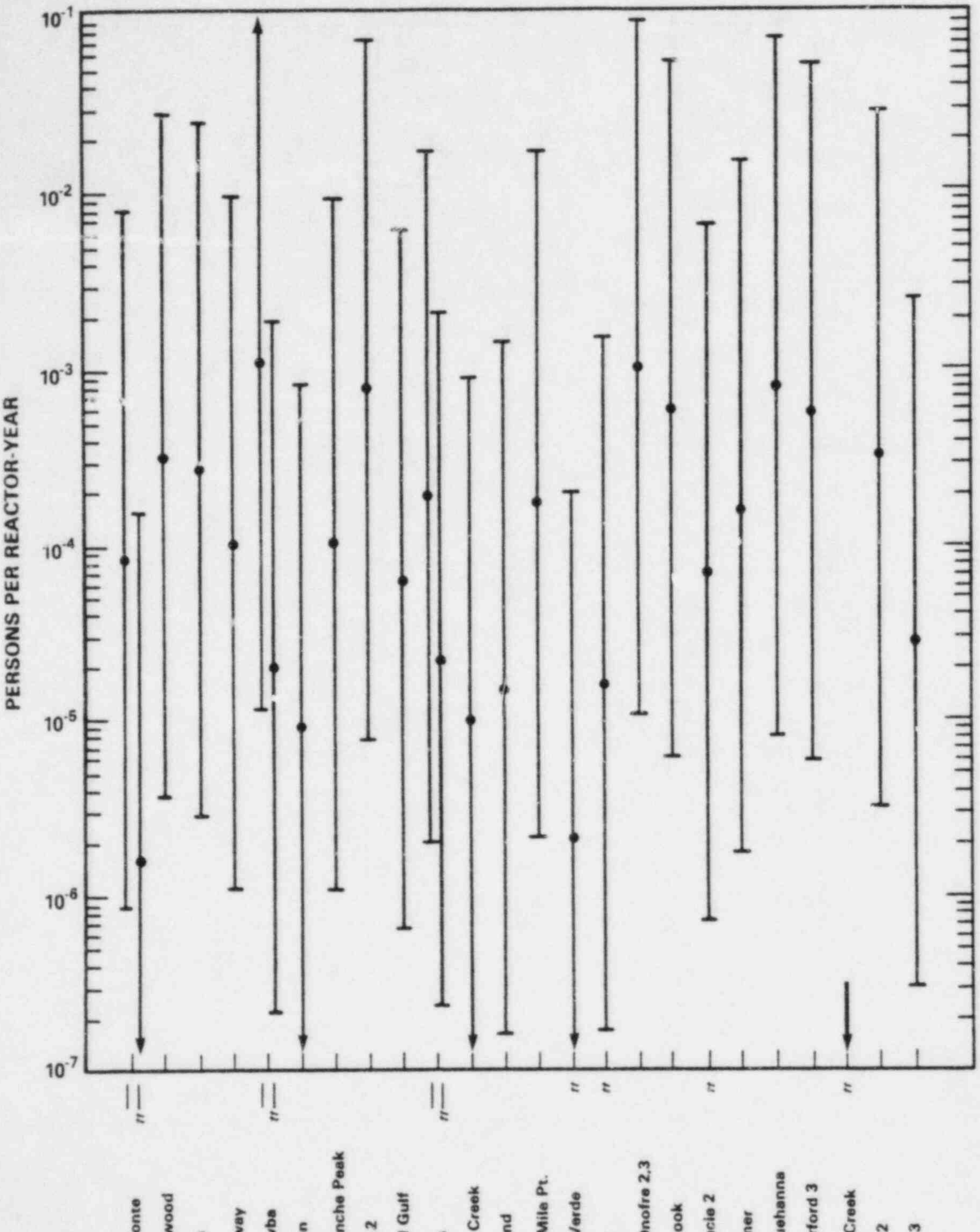


Figure 5.19 Estimated early fatality risk with supportive medical treatment (persons) from severe reator accidents for nuclear power plants either operating or receiving consideration for issuance of license to operate for which site-specific applications of NUREG/CR-1695 accident releases have been used to calculate offsite consequences. Bars are drawn to illustrate effect of uncertainty range discussed in test. See footnotes following Figure 5.25.

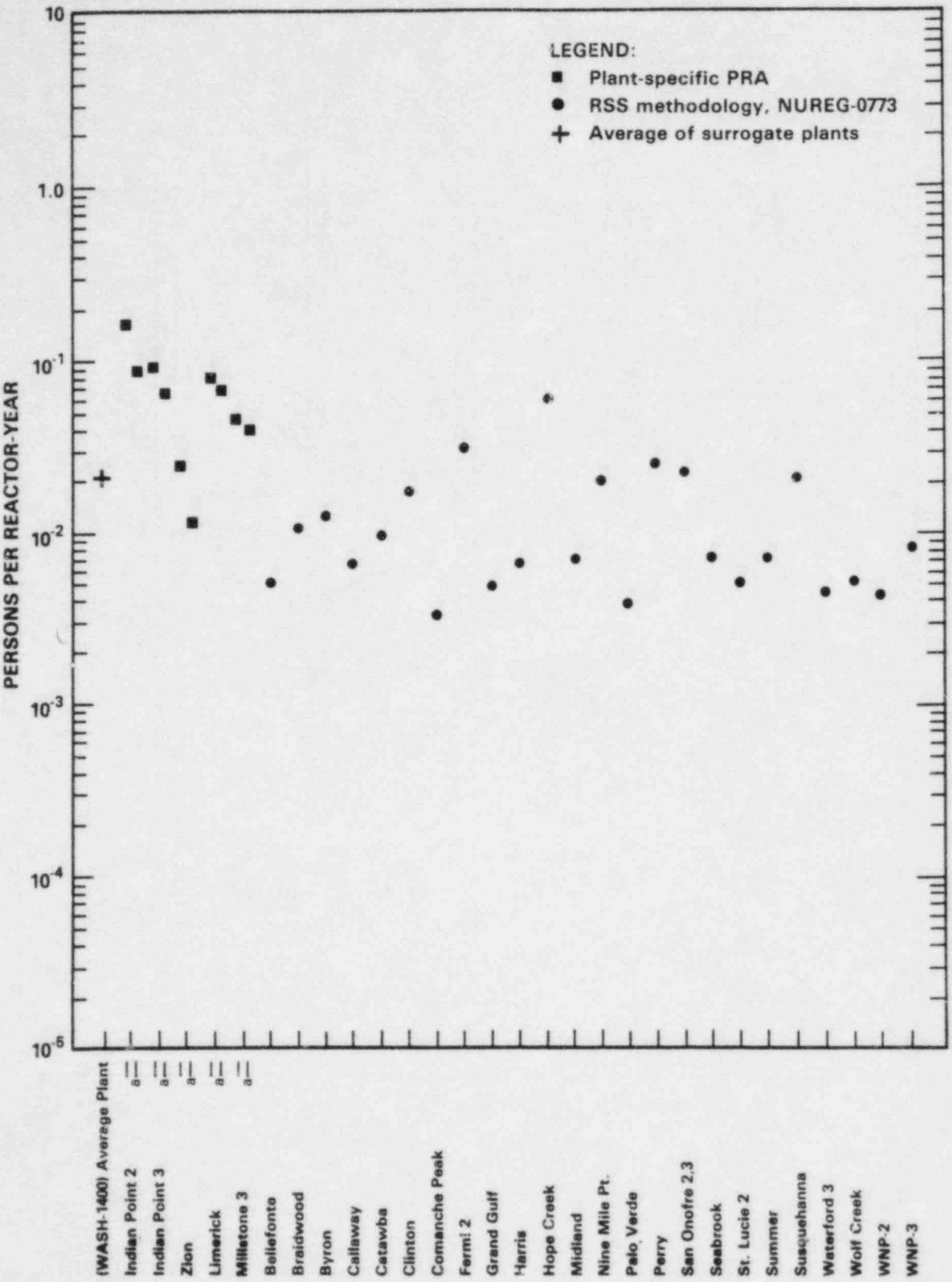


Figure 5.20 Estimated latent cancer, excluding thyroid, fatality risk (persons) from severe reactor accidents for several nuclear power plants either operating or receiving consideration for issuance of license to operate. See footnotes following Figure 5.25.

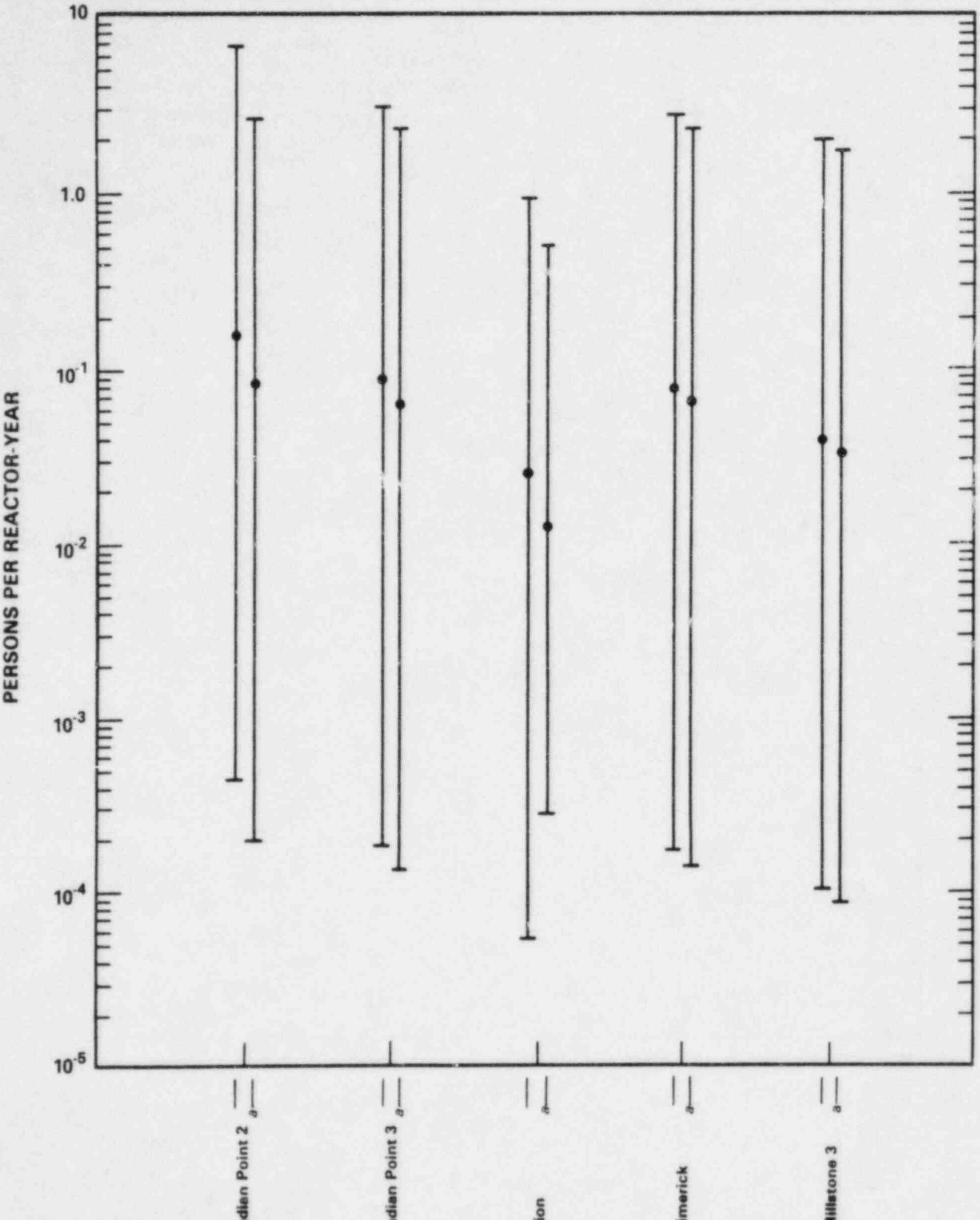


Figure 5.21 Estimated latent cancer, excluding thyroid, fatality risk (persons) from severe reactor accidents for nuclear power plants having plant-specific PRAs, showing estimated range of uncertainties. See footnotes following Figure 5.25.

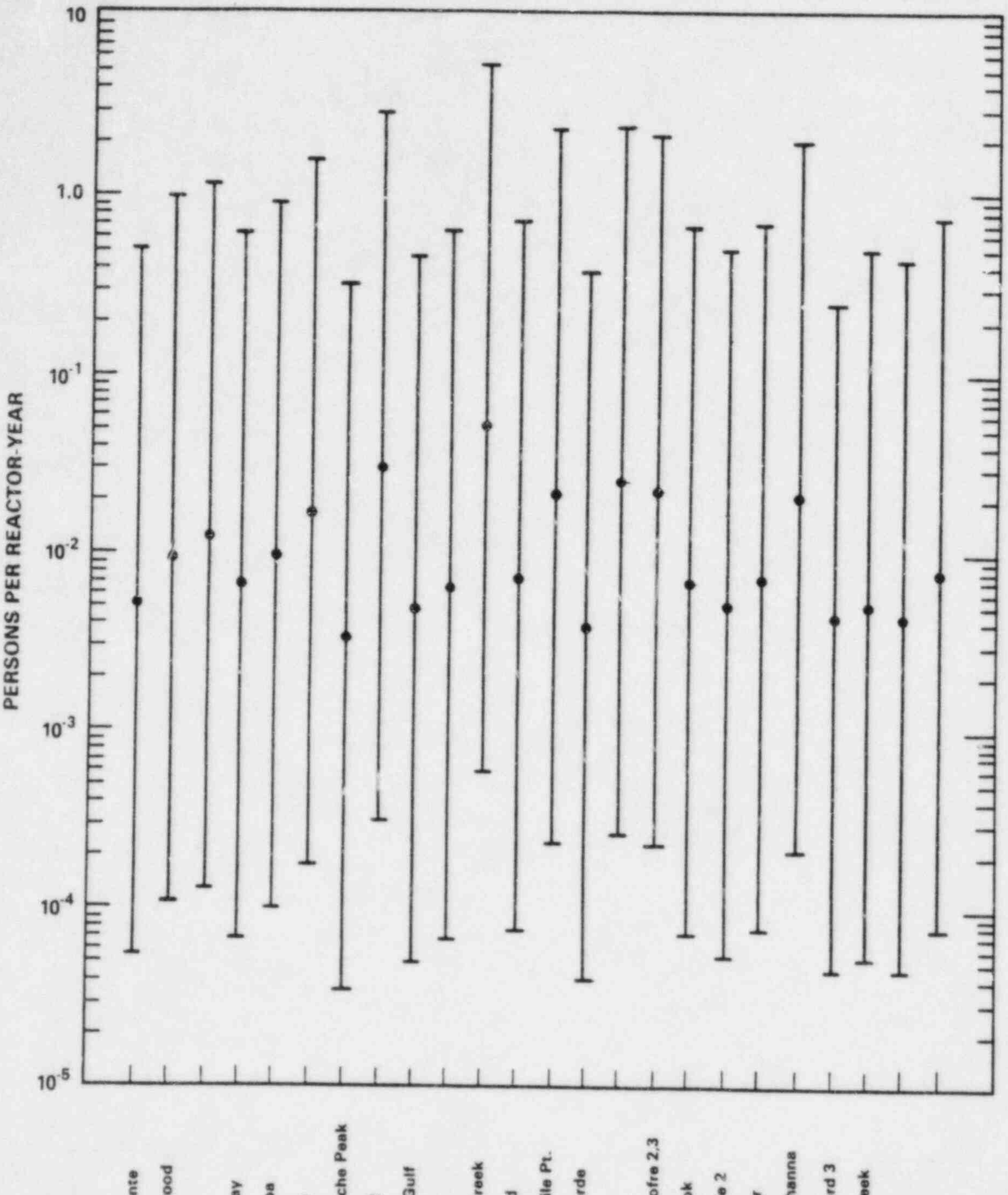


Figure 5.22 Estimated latent cancer, excluding thyroid, fatality risk (persons) from severe reactor accidents for several nuclear power plants either operating or receiving consideration for issuance of license to operate for which site-specific applications of NUREG/CR-1695 accident releases have been used to calculate offsite consequences. Bars are drawn to illustrate effect of uncertainty range discussed in text. See footnotes following Figure 5.25.

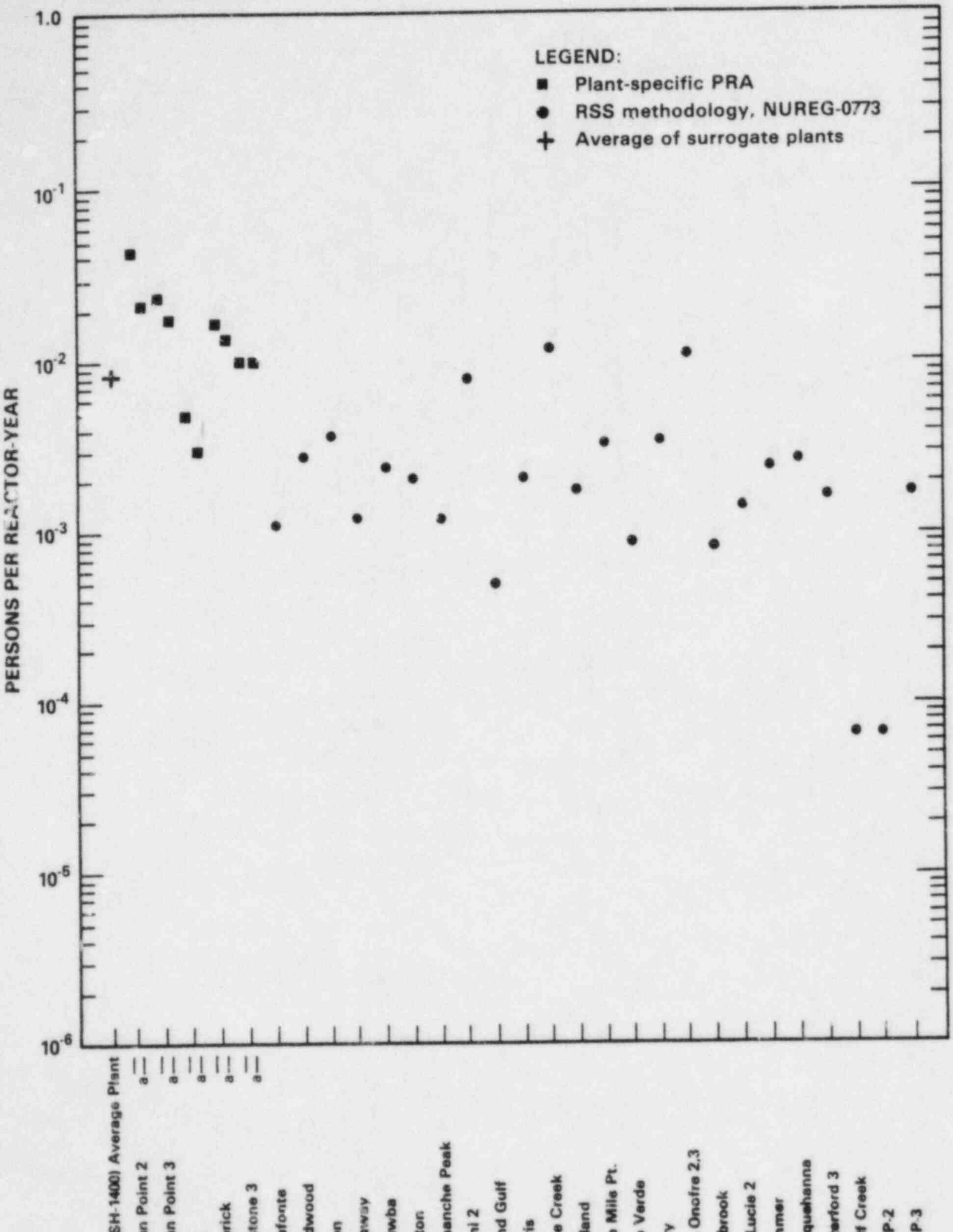


Figure 5.23 Estimated latent thyroid cancer fatality risk (persons) from severe reactor accidents for several nuclear power plants either operating or receiving consideration for issuance of license to operate. See footnotes following Figure 5.25.

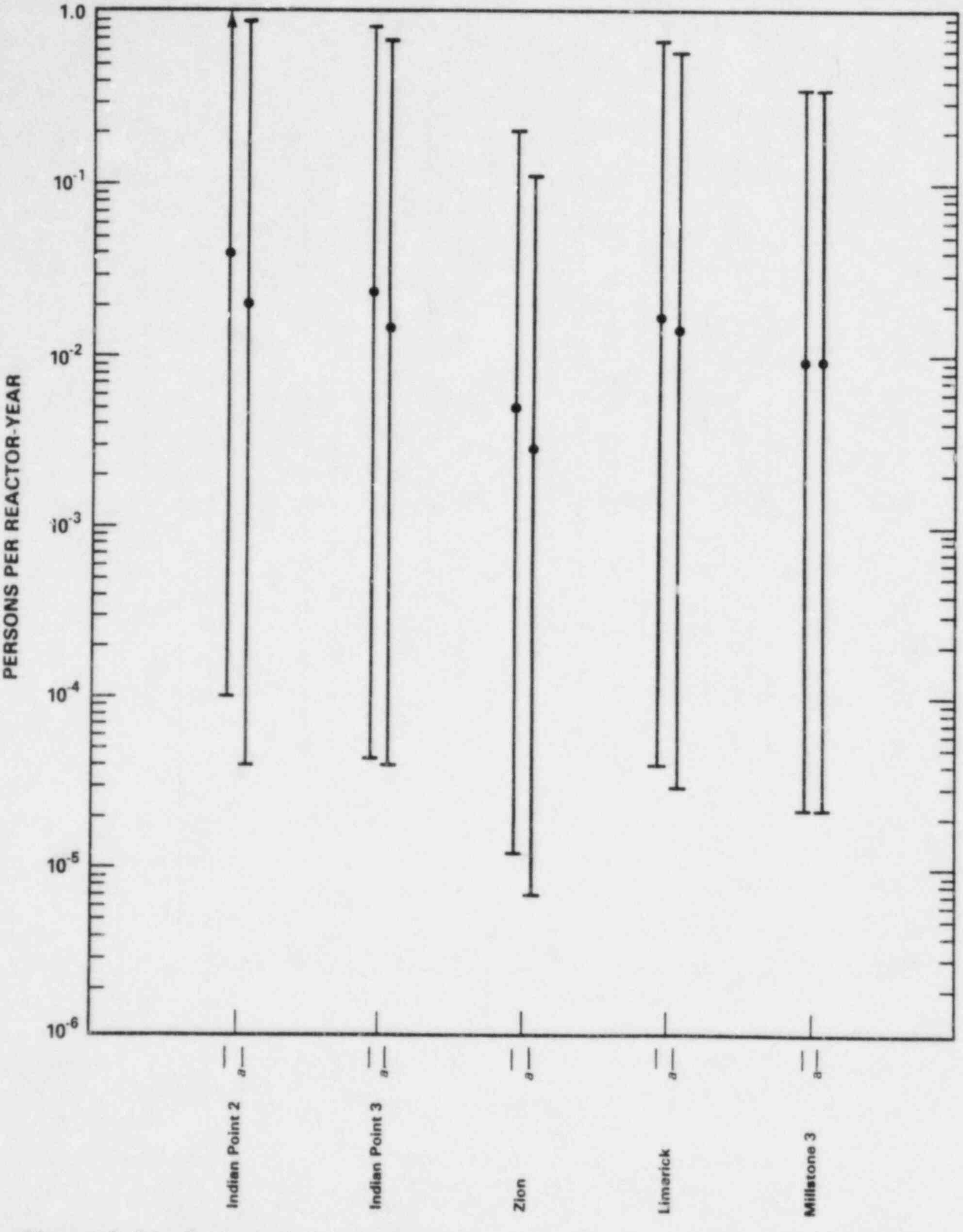


Figure 5.24 Estimated latent thyroid cancer fatality risk (persons) from severe reactor accidents for nuclear power plants having plant-specific PRAs, showing estimated range of uncertainties. See footnotes following Figure 5.25.

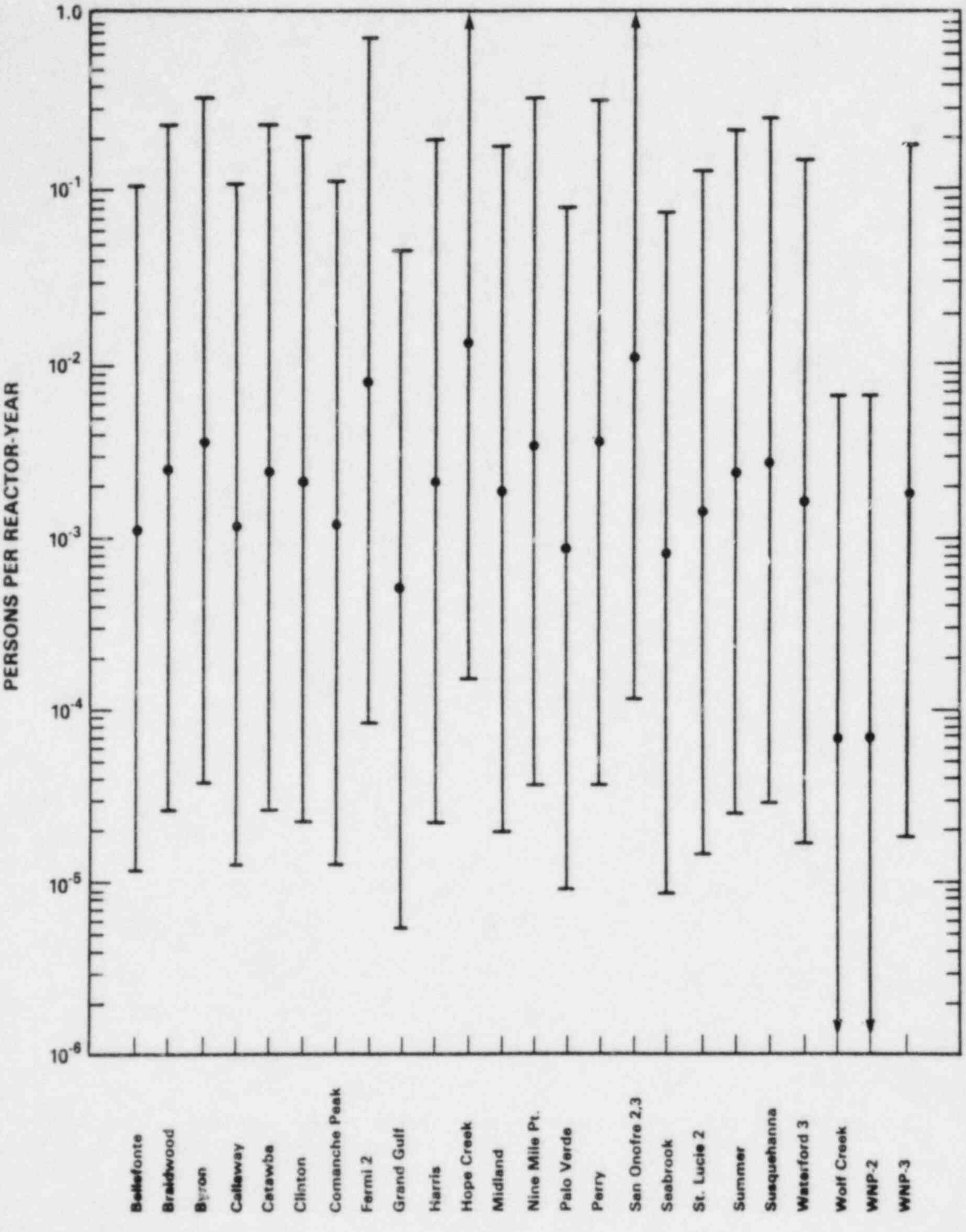


Figure 5.25 Estimated latent thyroid cancer fatality risk (persons) from severe reactor accidents from several nuclear power plants either operating or receiving consideration for issuance of license to operate for which site-specific applications of NUREG/CR-1695 accident releases have been used to calculate offsite consequences. Bars are drawn to illustrate effect of uncertainty range discussed in text. See footnotes on following page.

Notes for Figures 5.17 through 5.25

- 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.

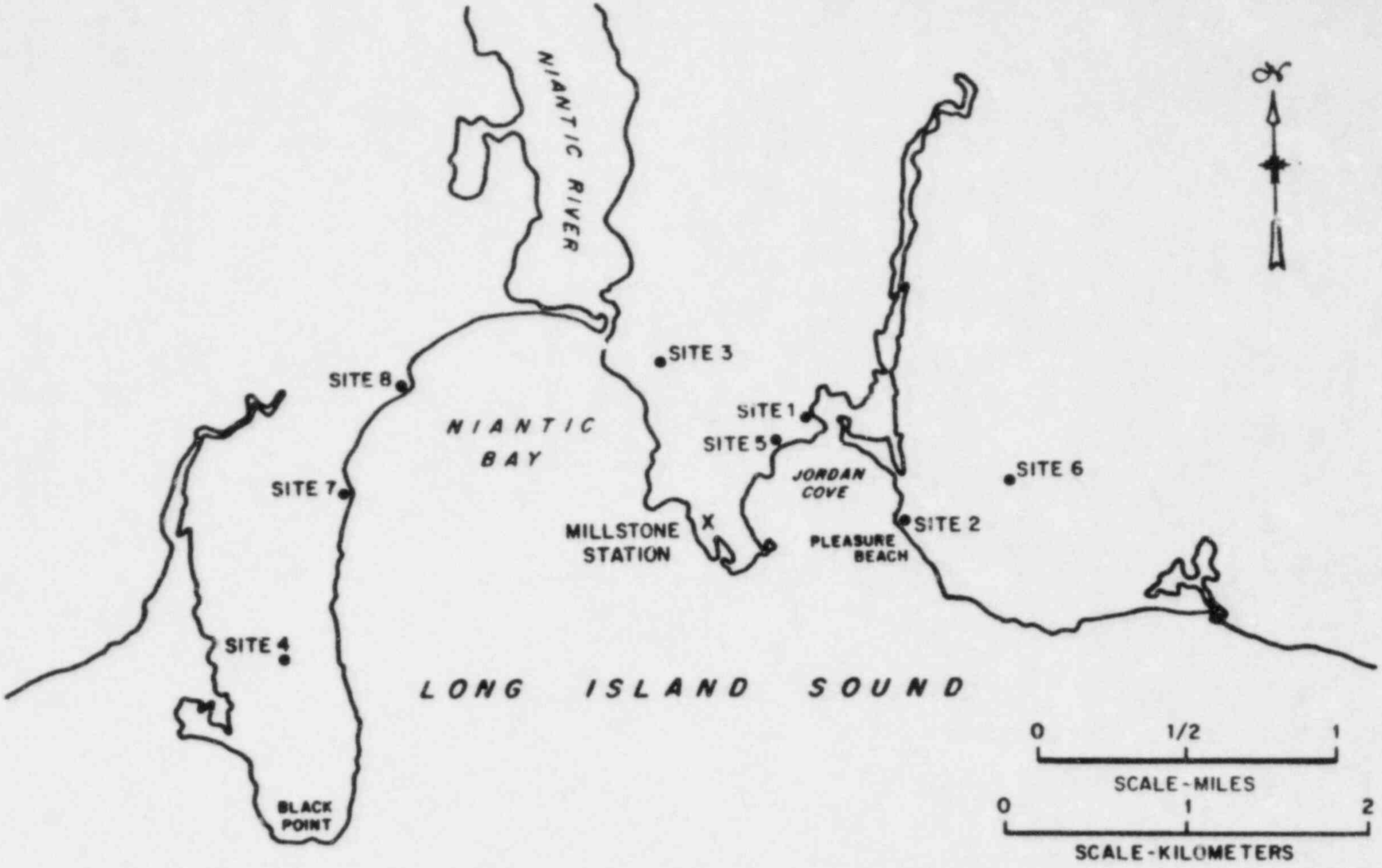


Figure 5.26 Location of nearest noise-sensitive locations in the vicinity of Millstone

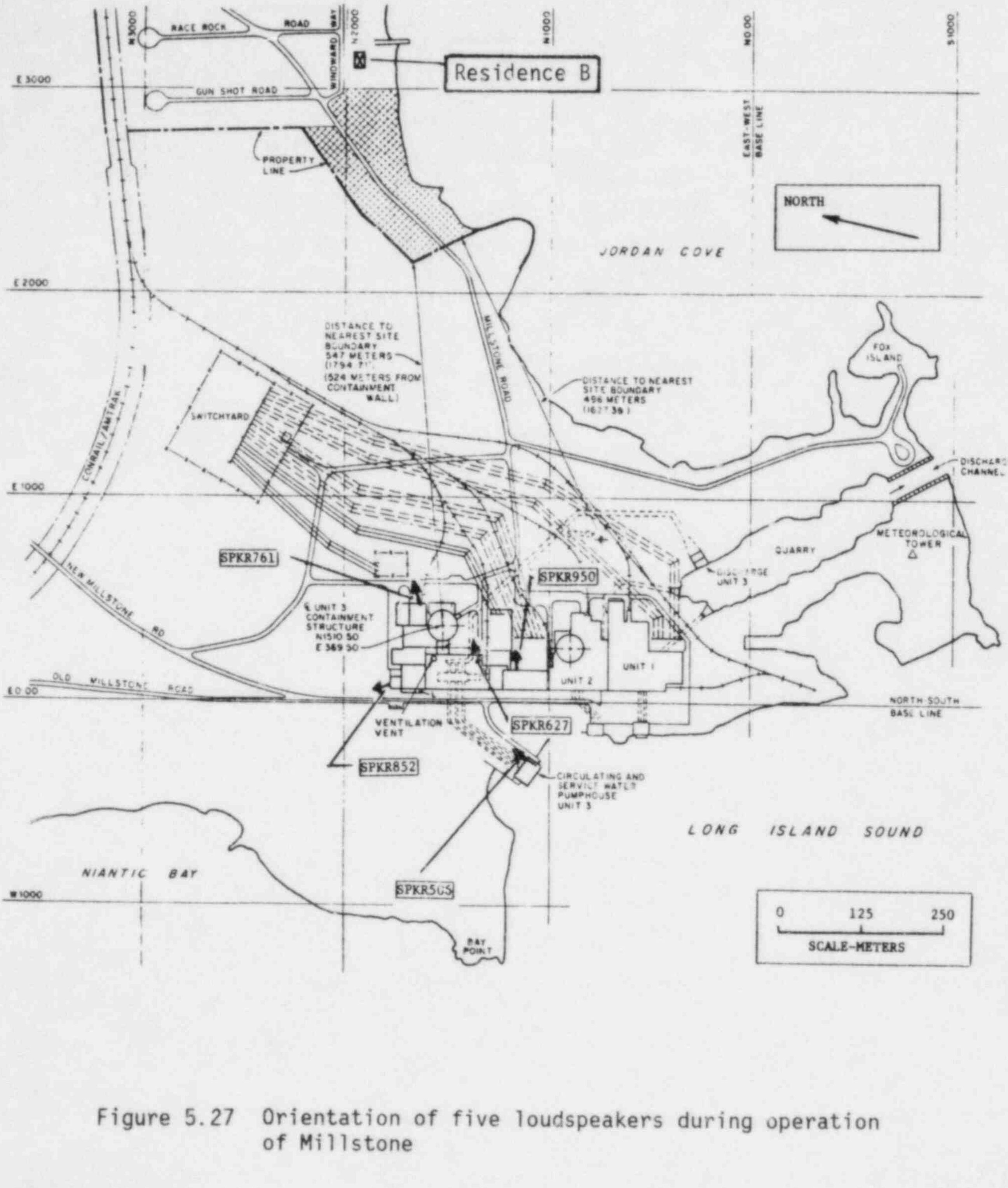


Figure 5.27 Orientation of five loudspeakers during operation of Millstone

Table 5.1 Millstone three-unit thermal discharge

Parameter	Tidal Stage		
	Flood	Ebb	Slack
Centerline distance, 2.2 C° isotherm, m	520	1100	1400
Centerline distance, 0.8 C° isotherm, m	2650	3900	2700
2.2 C° Isotherm area, ha	19	40	180
0.8 C° Isotherm area, ha	585	520	500
2.2 C° Isotherm depth penetration, m	2.0	4.6	2.1

Source: ER-OL Section 5.1

NOTES: Isotherm values represent temperature above ambient water temperature.
To convert m to ft, multiply values shown by 3.28.
To convert ha to acre, multiply values shown by 2.47.

Table 5.2 Water quality standards (Connecticut Department of Environmental Protection, 1977) for class SB waters in the vicinity of Millstone 3

Parameter	Water Quality Standard
Dissolved oxygen	Note less than 5.0 mg/L at any time.
Sludge deposits, solid refuse, floating solids, oils and grease, scum	None except for small amounts that may result from the discharge from a waste treatment facility providing appropriate treatment.
Sand or silt deposits	None other than that of natural origin, except that may result from normal agricultural, road maintenance, construction activity, or dredge material disposal, provided all reasonable controls are used.
Color and turbidity	A secchi disc shall be visible at a minimum of 1 m SB_b - criteria may be exceeded.
Coliform bacteria per 100 mL	Not to exceed a median value of 700 and not more than 2300 in more than 10% of the samples.
Taste and ordor	None in such concentrations that would impair any usages specifically assigned to this class and none that would cause taste and odor in edible fish or shellfish.
pH	6.8 to 8.5 standard units
Allowable temperature increase	None except where the increase will not exceed the recommended limit on the most sensitive receiving water use, and in no case exceed 83°F, or in any case raise the normal temperature of the receiving water more than 4 F°. During the period including July, August, and September, the normal temperature of the receiving water shall not be raised more than 1.5 F° unless it can be shown that spawning and growth of indigenous organisms will not be significantly affected.
Chemical constituents	None in concentrations or combinations which would be harmful to human, animal, or aquatic life or which would make the waters unsafe or unsuitable for fish or shellfish or their propagation, or impair the water for any other usage assigned to this class.

NOTE: To change °F to °C, multiply the value shown by 5/9 and subtract 32.

Source: ER-OLS Table 5.3-1

Table 5.3 Long Island Sound water quality*

Parameter**	Intake Station 8	Discharge Station 1	L.I. Sound Station 2
Ammonia - N	0.016	0.054	0.053
Nitrite - N	0.008	0.008	0.008
Nitrate - N	0.201	0.201	0.185
Organic - N	0.315	0.471	0.400
Total Phosphate	0.175	0.220	0.216
Ortho-Phosphate	<0.1	<0.1	<0.1
Condensed PO_4	<0.1	0.113	<0.1
Organic Carbon	9.85	16.9	11.6
Oil and Grease	8.83	6.64	3.02
Sulfates	2444	2409	2372
MBAS	0.08	0.07	0.09
Free Cl_2	ND**	ND	ND
Combined Cl_2	ND	ND	ND
Suspended Solids	28.1	28.2	30.1
Boron	2.52	2.51	2.51
Copper	0.038	0.043	0.033
Nickel	0.085	0.084	0.092
Iron	0.092	0.100	0.093
Manganese	0.020	0.025	0.023
Zinc	0.013	0.014	0.011
Aluminum	1.014	0.730	0.490
Total Chromium	0.060	0.057	0.062
Lead	0.100	0.090	0.091
Total Alkalinity	240	238	244
Chloride	17814	18278	17709
Potassium	565	630	582
Calcium	245	249	250
Magnesium	1059	1103	1068
Arsenic	ND	ND	ND
Molybdenum	0.135	0.350	0.100
Titanium	ND	ND	ND
Vanadium	0.055	0.061	0.081
Cadmium	0.020	0.025	0.023
Beryllium	ND	ND	ND
Mercury	ND	ND	ND
Total Solids	33430	33929	34049
Volatile Solids	5400	6085	6235
Tin	2.2	3.7	3.7
Phenol	ND	ND	ND

*Data based on baseline water quality study (Section 2.4).
**All concentrations are expressed in mg/L unless otherwise noted.
***ND - Not detected

Source: ER-OL Table 5.3.2-2

Table 5.4 Comparison of copper, nickel, and zinc concentrations 2 km from Millstone plant and at the plant intake and discharge, µg/L

Parameter	2 km from Plant	Plant Intake	Plant Outfall	
			Dissolved	Total Conc.
Cu	1.2	1.2	2.3	4.7
Ni	1.0	2.4		3.5
Zn	1.4	0.4	1.5	3.1

Source: Waslinchuk, 1980

Table 5.5 Estimated and measured flood levels

Flood Event	Still Water Level	
	m, msl	ft, msl
Estimated 10-year flood*	1.9	6.3
Estimated 50-year flood*	2.8	9.1
Estimated 100-year flood*	3.2	10.4
Estimated 500-year flood*	4.4	14.1
Estimated extreme high tide**	0.8	2.5
Estimated probable maximum hurricane surge	6.0	19.7
Measured hurricane, September 21, 1938**	3.0	9.7
Measured hurricane, September 14, 1944**	1.9	6.2
Measured hurricane, August 31, 1954**	2.7	8.9
Measured hurricane, September 12, 1960**	[illegible]	6.0

*FIA Study for Waterford
**New London Primary Tidal Station

Table 5.6 Estimated annual adult-equivalent losses (in thousands) from entrainment of eggs and larvae

Dominant Species	Annual Equivalent Losses of Adults, Millstone 1 and 2 (Average flow)			Annual Equivalent Losses of Adults, Millstone 1, 2, and 3 (Full flow)		
	Eggs	Larvae	Eggs and Larvae	Eggs	Larvae	Eggs and Larvae
Anchovies	542.4	9618.6	10161.0	1086.3	18856.6	19942.9
Sand lance	0.2	676.0	676.2	0.3	1794.7	1795.0
Winter flounder	0.03	4.2	4.2	0.1	10.2	10.3
Grubby	1.5	243.0	244.5	5.6	619.2	624.8
Cunner	55.7	162.8	218.5	164.7	339.0	503.7
Tautog	3.2	2.0	5.2	8.0	4.1	12.1

Source: ER-OL Table 5.1-11.

NOTE: Data for eggs (May 1979-May 1981) and larvae (1976-1980) were averaged to represent annual ichthyoplankton densities.

Table 5.7 Mean annual impingement of dominant and selected fish at Millstone 1 and 2 from 1976-1980 and estimated annual total for Millstone 3

	Millstone 1 and 2		
Species	Annual Mean	Percent of Total Impinged	Millstone 3 Estimated Annual Total
Fishes:			
Pseudopleuronectes americanus	10,117	23.59	10,200
Menidia spp.	7,209	16.81	7,268
Gasterosteus spp.	5,982	13.95	6,031
Myoxocephalus aenaeus	4,956	11.56	4,997
Anchoa spp.	2,965	6.92	2,989
Tautogolabrus adspersus	1,663	3.88	1,677
Tautoga onitis	785	1.83	792
Scophthalmus aquosus	717	1.67	723
Brevoortia tyrannus	162	0.38	163
Fundulus spp.	158	0.37	159
Ammodytes spp.	136	0.32	137
Stenotomus chrysops	98	0.23	99
Pomatomus saltatrix	91	0.21	92
Morone saxatilus	6	0.01	6

Source: ER-OL Table 5.1-7

Table 5.8 Historical and estimated mortality of selected fish impinged at Millstone station

Fishes	Historical Mortality Estimate[1]	Annual Mortality Rate (%)		Annual Mortality Estimate		
	Units 1 and 2 (min/max)	Units 1 and 3	Unit 2	Units 1 and 3	Unit 2	Units 1, 2 and 3
Ammodytes spp.	138(68/259)	75[2]	100	128	103	231
Anchoa spp.	2965(847/5689)	93[3]	100	4,012	1,641	5,653
Brevoortia tyrannus	161(116/242)	92[3]	100	197	112	309
Fundulus spp.	157(28/358)	10[3,4]	100	28	43	71
Gasterosteus spp.	5595(2815/9194)	22[2]	85	1,835	3,206	5,041
Menidia spp.	7208(1505/17,379)	98[2]	100	11,103	3,067	14,170
Morone saxatillis	6(2/11)	100[5]	100	12	1	13
Myoxocephalus aenacus	4509(1208/5562)	6[2]	79	374	2,971	3,345
Pomatomus saltatrix	90(26/188)	80[3]	100	122	31	153
Pseudopleuronectes americanus	9117(3638/21,695)	9[2]	77	1,321	4,294	5,614
Scophthalmus aquosus	683(371/1145)	23[3]	89	244	363	606
Stenotomus chrysops	97(23/150)	100[5]	100	130	67	197
Tautoga onitis	751(401/1016)	14[3]	90	167	388	554
Tautogolabrus adspersus	1635(1025/2920)	14[3]	96	337	921	1,257

Source: ER-OL Table 5.1-9

NOTES: [1] Based on 1976-1980 impingement data, 1977 mortality rates, and 3-day/week sampling at Millstone 1 and 2, with annual range estimates.

[2] From Millstone Point.

[3] From Oyster Creek Generating Station, NJ.

[4] From Pilgram Nuclear Generating Station, MA.

[5] No data available; derived from estimates of other similar fishes.

Table 5.9 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 nonradiation-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.)

Table 5.10 (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 [4]
Common (nonradiological) causes	1 fatal injury in 100 reactor years; 1 nonfatal injury in 10 reactor years; $475 property damage per reactor year.

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[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.

Table 5.11 Preoperational terrestrial radiological environmental monitoring program summary[†]

Table 2-1
Millstone Radiological Environmental
Monitoring Program--Terrestrial Stations

Locations	Distance and Direction$^{(a)}$	Sample Type$^{(b)}$ and Analysis$^{(c)}$		
		Gamma Dose	Air Particulate$^{(e)(i)}$	Soil
1. Onsite--Old Millstone Road	0.6 miles NNW	M	W1 - M2 - Q5	--
2. Onsite--Weather Shack	0.3 miles S	M	W1 - M2 - Q5	--
3. Onsite--Bird Sanctuary	0.3 miles NE	M	W1 - M2 - Q5(f)	A2,5
4. Onsite--Albacore Drive	1.0 miles N	M	W1 - M2 - Q5(f)	A2,5
5. Onsite--Navy Laboratory	0.2 miles SSE	M	--	--
6. Onsite--Quarry Discharge Canal Fence	0.3 miles SSE	M	--	--
7. Onsite--Fox Island	0.3 miles SE	M	--	--
8. Onsite--Millstone Environmental Lab.	0.3 miles SE	M	--	--
9. Onsite--Bay Point Beach (Information Center)	0.2 miles W	M	--	--
10. Pleasure Beach	1.2 miles E	M	W1 - M2 - Q5	A2,5
11. New London Country Club	1.6 miles ENE	M	W1 - M2 - Q5(f)	A2,5
12. Fisher's Island, New York *	8.7 miles ESE	M	W1 - M2 - Q5	--
13. Mystic, Connecticut *	11.5 miles ENE	M	W1 - M2 - Q5	--
14. Ledyard, Connecticut *	12.5 miles NE	M	W1 - M2 - Q5$^{(f)}$	A2,5
15. Montville, Connecticut *	14.0 miles N	M	W1 - M2 - Q5	A2,5
16. Old Lyme, Connecticut *	9.0 miles W	M	W1 - M2 - Q5	--

Locations	Distance and Direction$^{(a)}$	Milk$^{(d, g)}$	Groundwater	Fruit	Vegetables
17. Well No. 1	1.5 miles NNE	--	SA1,2,4,5	--	--
18. Well No. 2	1.0 miles NNE	--	SA1,2,4,5	--	--
19. Dairy Farm No. 1	4.5 miles WNW **	M3,5	--	--	--
20. Dairy Farm No. 2	7.0 miles W	M3,5	--	--	--
21. Dairy Farm No. 3	11.0 miles NE	M3,5	--	--	--
22. Dairy Farm No. 4 *	15.0 miles NNW	M3,5	--	--	--
23. Goat Farm No. 1	2.0 miles ENE	TM3-M5 (composite)	--	--	--
24. Goat Farm No. 2 *	14.0 miles NE	TM3-M5 (composite)	--	--	--
25. Fruit and Vegetables	--	--	--	SA2,5(h)	SA2,5(h)

a. From Millstone Unit 1 (stack) to nearest half mile
b. W = weekly, TM = twice a month, M = monthly, Q = quarterly, SA = semiannual, A = annual
c. 1 = gross beta; 2 = gamma spectrum; 3 = I-131; 4 = H-3; 5 = Sr-89. Sr 90, Cs-137.
d. During the period April through October and once in February.
e. Analyses are done on monthly and quarterly composites of the weekly air particulate samples collected at each station.
f. Includes a charcoal filter to be analyzed weekly for I-131 at inhalation dose levels.
g. Grass is substituted if milk is not available.
h. To be collected at the middle and end of the harvest season when available from representative commercial farms.
i. Comparisons between inner stations (within 1.5 miles) and outer stations (greater than 1.5 miles) will be made instead of using a control station concept.
* Control Station

** Changed to 6 miles N on 12/7/82

[†] Adapted from the Millstone Units 1 and 2 Annual Environmental Operating Reports, Part B: Radiological.

Table 5.12 Preoperational aquatic radiological environmental monitoring program summary[†]

Table 2-2
Millstone Radiological Environmental
Monitoring Program--Aquatic Stations

Locations	Distance and Direction(a)	Type, Frequency(b) and Analysis(c): Bottom Sediment	Flora	Mussels	Oysters or Clams(e)	Lobster(e)	Fin Fish(d,e)	Water
1. Golden Spur*	4.7 miles NNW	SA2,3	- -	Q2,3,5	Q2,3,5	--	--	--
2. Niantic Shoals	1.8 miles NW	SA2,3	SA2,3	Q2,3,5	Q2,3,5	--	--	--
3. Within 500 Feet of Discharge Canal	- - -	SA2,3	SA2,3	Q2,3,5	Q2,3,5	Q2,3,5	Q2,3,5	Q1,2,3,4
4. Seaside Point	1.6 miles ESE	SA2,3	SA2,3	--	--	--	--	Q1,2,3,4
5. Thames River (Yacht Club)	4.0 miles ENE	SA2,3	SA2,3	--	Q2,3,5	--	--	--
6. Niantic Bay	0.3 miles WNW	--		--	--	Q2,3,5	Q2,3,5	Q1,2,3,4
7. Black Point	2.6 miles WSW	SA2,3	SA2,3	--	Q2,3,5	--	--	--
8. Giants Neck*	3.5 miles W	SA2,3	SA2,3	--	Q2,3,5	Q2,3,5	--	Q1,2,3,4
9. Commercial Shellfish Bed #316	0.1 miles S	--	--	--	Q2,3,5	--	--	--
10. Waterford Shell fish Bed #1	0.5 miles WNW	--	--	--	Q2,3,5	--	--	--

a. From Discharge Quarry to nearest half mile.
b. Q = quarterly, SA = semi-annual
c. 1 = gross beta, 2 = gamma spectrum, 3 = Sr-89, Sr-90, Cs-137, Co-60, 4 = H-3, 5 = I-131
d. Flounder and one other type of edible fin fish.
e. Sampling of crustacea, mollusk and fin fish to be staggered for each month of the quarter.
* Control Stations

[†] Adapted from the Millstone Units 1 and 2 Annual Environmental Operating Reports, Part B: Radiological.

Table 5.13 Activity of radionuclides in a Millstone 3 reactor core at 3579 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	80	0.117
Xenon-133	200	5.28
Xenon-135	40	0.384
B. IODINES		
Iodine-131	100	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	7	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	0.9	71.0
Cobalt-60	0.3	1,920
Molybdenum-99	200	2.8
Technetium-99m	200	0.25

Table 5.13 (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	70	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	0.6	163
Curium-244	0.03	6,630

NOTE: The above grouping of radionuclides corresponds to that in Table 5.15. The listed inventory has been rounded to one significant digit to reflect its accuracy in describing the Millstone 3 core. All calculations, however, were done using the CRAC data file at much higher precision.

Table 5.14 Approximate doses during a 2-hour exposure at the exclusion area boundary*

Accidents and Faults	Whole-Body Dose (rems)
Infrequent Accidents	
Fuel-handling accident	0.05
Steam generator tube rupture**	0.009
Limiting Faults	
Main steamline break	0.0005
Control rod ejection	<0.0005
Large-break LOCA	<0.0005

*503 m (1650 feet) from Millstone 3.

**See NUREG-0651 for descriptions of three steam generator tube rupture accidents that have occurred.

Table 5.15 Summary of the atmospheric release specifications used in consequence analysis for Millstone 3[a]

Category[b]	Release Time (hr)	Release Duration (hr)	Warning Time for Evacuation (hr)	Release Energy (Btu/hr)	Release Height (m)	Fractions of Core Inventory Release: Xe-Kr	Organic I[c]	Inorganic I	Cs-Rb	Te-Sb	Ba-Sr	Ru[d]	La[e]
M-1A	2.5	1.0	1.0	0.5E-6[f]	10	1.0	7E-3	0.48	0.79	0.44	9E-2	4E-2	5E-3
M-1B	2.5	1.0	1.0	0.5E-6	10	0.9	7E-3	7E-2	5E-2	3E-2	6E-3	2E-3	4E-4
M-2A	0.8	2.0	0.2	150E-6	10	0.7	5E-3	0.5	0.6	0.2	7E-2	2E-2	3E-3
M-2B	0.8	0.5	0.2	520E-6	10	0.9	5E-3	0.7	0.4	0.4	0.05	0.4	3E-3
M-3	5.6	2.0	0.4	190E-6	10	0.8	5E-3	0.5	0.6	0.2	8E-2	3E-2	3E-3
M-4	1.5(I)[g] 2.5(E)	2.0	0.25(I)[g] 1.0 (E)	70E-6	10	0.9	6E-3	0.2	0.6	0.5	7E-2	5E-2	7E-3
M-5	5.6	0.5	0.4	150E-6	10	0.9	6E-3	1E-2	0.5	0.5	5E-2	4E-2	6E-3
M-6	0.8	0.5	0.2	150E-6	10	0.9	6E-3	1E-2	0.5	0.5	5E-2	4E-2	7E-3
M-7	20.1	0.5	16.0	150E-6	10	0.9	6E-3	9E-3	0.3	0.3	3E-2	2E-2	4E-3
M-8	1.0	0.5	0.75	22E-6	10	0.9	7E-3	8E-3	1E-5	1E-5	1E-6	1E-6	2E-7
M-9	21	0.5	20.0	22E-6	10	0.9	6E-3	2E-3	2E-6	1E-6	2E-7	9E-8	1E-8
M-10	95	10.0	80	h	10	0.3	2E-3	8E-4	8E-4	1E-3	9E-5	7E-5	1E-5
M-11	95	10.0	80	h	10	6E-3	2E-5	2E-5	1E-5	2E-5	1E-6	1E-6	2E-7
M-12	0.5	5.0	0	h	113	1E-3	9E-6	6E-6	1E-6	9E-7	2E-7	8E-8	1E-8

[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 E 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.

[f] 0.5E-6 = 0.5 x 10^{-6} = 0.0000005.

[g] Times given are for intenal events (I) and external events (E).

[h] Low release energy not used in calculation.

Table 5.16 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, LLNL* (per reactor-year)	Probability of the Release Category Initiated by Severe Earthquakes, (per reactor-year)
M-1A	4(-7)**	0
M-1B	5(-6)	0
M-2A	6(-8)	4(-9)***
M-2B	2(-8)	4(-10)***
M-3	0	0
M-4	5(-8)	8(-8)
M-5	2(-6)	2(-10)***
M-6	1(-7)	5(-7)
M-7	5(-5)	3(-6)
M-8/M	0	0
M-9	0	0
M-10	1(-5)	3(-7)
M-11	0	0
M-12	1(-4)	9(-11)***
Total probability per reactor-year	2(-4)	4(-6)

*Lawrence Livermore National Laboratory.

**4(-7) = 4 x 10^{-7} = 0.0000004

***Any release category with probability less than 10^{-8} 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.

Table 5.17 Annual average wind-direction probabilities for the Millstone site based on data for the year 1981

Wind Blowing Toward the Direction	Probability (fraction of the year)
N	0.0305
NNE	0.0388
NE	0.0704
ENE	0.0995
E	0.0750
ESE	0.1026
SE	0.1160
SSE	0.[illegible]27
S	0.0664
SSW	0.0766
SW	0.0371
WSW	0.0289
W	0.0414
WNW	0.0483
NW	0.0451
NNW	0.0307
Total	1.00

Table 5.18 Emergency response assumptions for Millstone 3

Emergency Response Set No.*	Evacuation Distance (mi)	Delay Time (hr)	Effective Evacuation Speed (mph)	Effective Downwind Distance Moved** (mi)	Relocation Zone Size (mi) Zone		Zone B Relocation Time (hr)	Zone B Relocation Dose Criterion (bone marrow dose projected for 7 days) (rems)	Shielding Protection Factor (fraction)	
					A***	B***			During Evacuation, Plume/Ground	Other Times, Plume/Ground
1	10	1	2	15	0	>10	12	200	1†/0.5†	0.75††/0
2	N/A	N/A	N/A	N/A	10†††	>10	12	200	N/A	0.75††/0
3	N/A	N/A	N/A	N/A	0	>0	24	200	N/A	1.0¶/0

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

**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.

†During evacuation, automobiles are assumed to provide essentially no shielding to gamma rays from the plume and 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 evacuation, 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.

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

¶During an abnormal situation in the site region caused by an 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. Therefore, 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. Therefore, 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 a normal situation and 0.7 for an ordinary and uncovered ground surface.

NOTES: Please see Section 5.9.4.5(7) for discussion of uncertainties.
To change miles to kilometers, multiply the values shown in miles by 1.609.
N/A = not applicable.

Table 5.19 Summary of environmental impacts and probabilities

Probability of Impact Per Reactor-Year	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						
	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
10^{-5}	7(0)***	3(1)	4(2)	1(3)	1(2)	3(2)	0	1(0)	1(2)	3(3)	2(2)
5×10^{-6}	1(1)	5(1)	6(2)	2(3)	2(2)	4(2)	0	1(1)	3(2)	5(3)	3(2)
10^{-6}	2(1)	1(2)	1(3)	4(3)	3(2)	8(2)	7(0)	7(1)	2(3)	8(3)	4(2)
10^{-7}	3(1)	3(2)	2(3)	8(3)	7(2)	2(3)	6(2)	1(3)	6(3)	1(4)	5(2)
10^{-8}	3(1)	5(2)	3(3)	1(4)	1(3)	3(3)	3(3)	6(3)	2(4)	2(4)	1(3)
See Figure	5.7	5.7	5.8	5.8	5.8	5.8	5.9	5.9	5.10	5.11	5.12

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

**About 2.6 million m^2 equals 1 mi^2.

***$7(0) = 7 \times 10^0 = 7$.

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 5.20 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)	2(-4)*	2(-4)
2.	Early fatalities with minimal medical treatment (persons)	8(-4)	8(-4)
3.	Early injuries (persons)	9(-3)	9(-3)
4.	Latent cancer fatalities (excluding thyroid) (persons)	1(-2)	4(-2)
5.	Latent thyroid cancer fatalities (persons)	3(-3)	1(-2)
6.	Total person-rems	2(2)	1(3)
7.	Cost of offsite mitigation measures (1980 $)	3(4)	8(4)
8.	Land area for long-term interdiction (m^2)**	4(3)	4(3)

*2(-4) = 2×10^{-4} = 0.0002

**About 2.6 million m^2 equals 1 mi^2.

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 5.21 (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 5.21 (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.

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[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.

Table 5.22 Summary of loudspeaker noise calculations for speaker SPR761 and residence B, Hz

Parameter	250	500	1000	2000	4000
1. Sound power level of loudspeaker (dB/1pW)	104	106	103	100	96
2. Correction for 770 m distance to residence	-68	-70	-72	-78	-93
3. Sum of (1) and (2)	36	36	31	22	3
4. Subtraction of residual ambient	-38	-31	-33	-23	-28
5. Incremental sound pressure level at residence (above ambient)**	-2	+5*	-2	-1	-25

*The 5-dB increment in the 500-Hz octave band may be sufficient to lead to annoyance.

**The lowest ambient measure at site 5 was used to represent the residual ambient.

Table 5.23 Water quality sampling parameters

Monthly Sampling Parameters	Quarterly Sampling Parameters	Benthic Sampling Parameters
NH_3-N	Total alkalinity	Total nitrogen
NO_2-N	Chloride	Total phosphate
NO_3-N	Potassium	Total organic carbon
Organic-N	Calcium	Total volatile solids
Ortho-PO_4	Magnesium	Boron
Condensed PO_4	Arsenic	Aluminum
Total PO_4	Molybdenum	Iron
Dissolved nitrogen	Titanium	Copper
Dissolved oxygen	Vanadium	Nickel
Biochemical oxygen Demand	Cadmium	Lead
	Beryllium	Mercury
Total organic carbon	Mercury	Zinc
Temperature °C	Total solids	Beryllium
Salinity	Total volatile solids	Cadmium
pH	Tin	Vanadium
Sulfate	Phenol	Titanium
MBAS*		Molybdenum
Free chlorine		Manganese
Total chlorine		Arsenic
Boron		Chromium (total and hexavalent)
Oil and grease		Oil and grease
Suspended solids		Phenols
Total chromium		
Copper		
Lead		
Nickel		
Iron		
Manganese		
Zinc		
Aluminum		

Source: ER-OL Table 6.1-1

*Methylene blue active substances (denotes presence of detergent residue).

6 EVALUATION OF THE PROPOSED ACTION

6.1 Unavoidable Adverse Impacts

The staff has reassessed the physical, social, and biological impacts that can be attributed to the operation of Millstone 3. 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 license.

(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 Millstone 3 since the construction permit stage environmental review.

6.4 Benefit-Cost Summary

6.4.1 Benefits

A major benefit to be derived from the operation of Millstone 3 is the approximately 5.6 billion kWh of baseload electrical energy that would be produced annually. (This projection assumes, conservatively, that the unit would operate at an annual average capacity factor of 55%.) The addition of the unit would also improve the applicant's ability to supply system load requirements by contributing 1154 MW of capacity to the applicant's bulk power supply system.

Another benefit is the overall savings (actually, costs avoided) in system production costs that would result from operation of Unit 3. If it is assumed that the energy available from the unit replaces energy from installed fossil units on the applicant's systems, then decreased production costs will be incurred. These decreased costs will total approximately $151 million (1986 dollars) a year during the life of the plant.

6.4.2 Economic Costs

The economic costs associated with station operation include fuel costs and operating and maintenance costs, which are expected to average approximately 8.0 mills per kWh and 12.0 mills per kWh, respectively (1986 dollars). This cost estimate is based on the annual escalation of the 1982 average cost of nuclear fuel and operations and maintenance costs in the northeast region of the U.S.

The applicant estimates decommissioning costs for the "Immediate Dismantlement/Prompt Removal" option (NUREG-0586) will total $103 million (1981 dollars).

6.4.3 Socioeconomic Costs

No significant socioeconomic costs are expected from either the operation of Millstone 3 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 staff has prepared an updated forecast of the effects of operation of Millstone 3. The staff has determined that Millstone 3 can be operated with minimal environmental impact. 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 References

U.S. Nuclear Regulatory Commission, NUREG-0586, "Draft Generic Environmental Impact Statement on Decommissioning Nuclear Facilities," January 1981.

Table 6.1 Benefit-cost summary for Millstone 3

Primary impact and effect on population or resources	Quantity (Section)	Impacts*
BENEFITS		
Direct		
Electrical energy	5.6 billion kWh/yr	Large
Additional generating capacity	1154 MWe	Large
Operating cost avoided	$151 million/unit/yr**	Moderate
COSTS		
Economic		
Fuel	8.0 mills/kWh**	Small
Operation and maintenance	12.0 mills/kWh**	Moderate
Decommissioning	$103 million (1981 dollars)	Small
Environmental		
Damages suffered by other water users		
Surface water consumption	(Sec. 5.3.1)	None
Surface water contamination	(Sec. 5.3.2)	Small
Groundwater consumption	(Sec. 4.3.2)	None
Groundwater contamination	(Sec. 4.3.3)	None
Damage to aquatic resources		
Entrainment	(Sec. 5.5.2)	Small
Impingement	(Sec. 5.5.2)	Moderate
Thermal effects	(Sec. 5.5.2)	Small
Chemical and biocide discharges	(Sec. 5.5.2)	Small
Damage to terrestrial resources		
Station operations	(Sec. 5.5.1.1)	Small
Transmission line maintenance	(Sec. 5.5.1.2)	Small
Socioeconomic		
Loss of historic or archeological resources	(Sec. 5.7)	Small
Increased demands on public facilities and services	(Sec. 5.8)	Small
Increased demands on private facilities and services	(Sec. 5.8)	Small

Table 6.1 (Continued)

Primary impact and effect on population or resources	Quantity Section	Impacts*
Noise		
Plant operation	(Sec. 5.12)	Small
Site paging system	(Sec. 5.12)	Moderate
Nonradiological health		
Water quality changes	(Sec. 5.3.2)	None
Air quality changes	(Sec. 5.4)	None
Radiological health		
Routine operation	(Sec. 5.9.3)	Small
Postulated accidents	(Sec. 5.9.4)	Small
Uranium fuel cycle	(Sec. 5.10)	Small

*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.

**1986 dollars

7 LIST OF CONTRIBUTORS

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8 LIST OF AGENCIES AND ORGANIZATIONS ASKED TO COMMENT ON THE DRAFT ENVIRONMENTAL STATEMENT

The following Federal, state, and local agencies are being asked to comment on this draft environmental statement:

- Advisory Council on Historic Preservation
- Attorney General, State of Connecticut
- Attorney General, State of New York
- Attorney General, State of Rhode Island
- Brookhaven National Laboratory
- Connecticut Energy Agency Division, Office of Policy Management
- Connecticut Regional/Metropolitan Clearinghouse
- Connecticut State Clearinghouse
- Department of Environmental Conservation, State of New York
- Director, Technical Development Programs, State of New York
- Federal Emergency Management Administration
- Federal Energy Regulatory Commission
- First Selectman, Town of Waterford, Connecticut
- Governor's Energy Office, State of Rhode Island
- U.S. Army Corps of Engineers, New England Division
- U.S. Department of Agriculture
    - National Forests, Eastern Region
    - Natural Resources and Economics Division
    - Rural Electrification Administration
    - Soil Conservation Service, State Office
- U.S. Department of Commerce
    - Office of Ecology and Conservation
- U.S. Department of Energy
- U.S. Department of Health and Human Services
    - Food and Drug Administration
- U.S. Department of Housing and Urban Development
    - Region II
- U.S. Department of the Interior
    - Office of Environmental Project Review
- U.S. Department of Transportation
    - Regional Office, Philadelphia
- U.S. Environmental Protection Agency
    - Eastern Environmental Radiation Facility, Montgomery, Alabama
    - EIS Review Coordinator, Region I
    - Office of Radiation Programs, Las Vegas Facility
    - Office of Radiation Programs, Washington, D. C.

9 RESERVED FOR STAFF RESPONSES TO COMMENTS ON THE DRAFT ENVIRONMENTAL STATEMENT

APPENDIX A

RESERVED FOR COMMENTS ON THE DRAFT ENVIRONMENTAL STATEMENT

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 Millstone 3 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 Millstone 3 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 (see Section 5.10 of the main body of this report) and the NRC staff's analysis of the radiological impact from radon and technetium 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 Millstone 3 nuclear 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 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

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*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.

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 United States; 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 United States 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

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*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.

has calculated for 1 year of operation of the model 1000-MWe LWR, the 100-year involuntary environmental dose commitment* to the U.S. population from the LWR-supporting fuel cycle.

It is estimated from these calculations that the overall involuntary total-body gaseous dose commitment to the U.S. population from the fuel cycle (excluding reactor releases and the dose commitment due to radon-222 and technetium-99) would be approximately 400 person-rems for each year of operation of the model 1000-MWe LWR (reference reactor year, or, RRY). Based on Table S-3 values, the additional involuntary 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 involuntary 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 500 person-rems (whole-body) per RRY.

At this time the radiological impacts associated with radon-222 and technetium-99 releases are not addressed 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.

When added to the 500 person-rems total-body dose commitment for the balance of the fuel cycle, the overall estimated total-body involuntary 100-year environmental dose commitment to the U.S. population from the fuel cycle for the model 1000-MWe LWR is approximately 640 person-rems. Over this period of time, this dose is equivalent to 0.00002% of the natural-background total-body dose of about 3 billion person-rems to the U.S. population.*

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 LWR-supporting fuel cycle.

It is estimated from these calculations that the overall involuntary total-body gaseous dose commitment to the U.S. population from the fuel cycle (excluding reactor releases and the dose commitment due to radon-222 and technetium-99) would be approximately 400 person-rems for each year of operation of the model 1000-MWe LWR (reference reactor year, or, RRY). Based on Table S-3 values, the additional involuntary 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 involuntary 100-year

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*Based on an annual average natural-background individual dose commitment of 100 millirems and a stabilized U.S. population of 300 million.

environmental dose commitment to the U.S. population from radioactive gaseous and liquid releases due to these portions of the fuel cycle is about 500 person-rems (whole-body) per RRY.

At this time the radiological impacts associated with radon-222 and technetium-99 releases are not addressed 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.

When added to the 500 person-rems total-body dose commitment for the balance of the fuel cycle, the overall estimated total-body involuntary 100-year environmental dose commitment to the U.S. population from the fuel cycle for the model 1000-MWe LWR is approximately 640 person-rems. Over this period of time, this dose is equivalent to 0.00002% of the natural-background total-body dose of about 3 billion person-rems to the U.S. population.*

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 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 × 110 or 37 Ci per year per RRY.

Based on the above, 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 total dose commitments for a 100- to 1000-year period would be as shown in Table C-3.

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

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*Based on an annual average natural-background individual dose commitment of 100 millirems and a stabilized U.S. population of 300 million.

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.

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 is about 0.11 cancer fatality per RRY. When the risk from radon-222 emissions from stabilized tailings over a 100-year release period is added, the estimated risk of cancer mortality over a 100-year period is unchanged. Similarly, a risk of about 1.2 cancer fatalities per RRY is estimated over a 1000-year release period. When potential radon releases from reclaimed and unreclaimed open-pit mines are included, the overall risks of radon-induced cancer fatalities per RRY range as follows:

0.11 to 0.19 fatality for a 100-year period
0.19 to 0.57 fatality for a 500-year period
1.2 to 2.0 fatalities for a 1000-year period

To illustrate: 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 1000 years as a result of releases of radon-222.

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.

The staff is currently in the process of formulating a specific model for analyzing the potential impact and health effects from the release of technetium-99 during the fuel cycle. However, for the interim period until the model is completed, the staff has calculated that the potential 100-year environmental dose commitment to the U.S. population from the release of technetium-99 should not exceed 100 person-rems per RRY. 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. When these figures are added to the 640 person-rem total-body dose commitment for the balance of the fuel cycle, including radon-222, the overall estimated total-body involuntary

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*Based on an annual average natural-background individual dose commitment of 100 mrems and a stabilized U.S. population of 300 million.

100-year environmental dose commitment to the U.S. population from the fuel cycle for the model 1000-MWe LWR is about 740 person-rems. Over this period of time, this dose is equivalent to 0.00002% of the natural-background total-body dose of about three billion person-rems to the U.S. population.*

The staff also considered the potential health effects associated with this release of technetium-99. Using the modeling systems described in NUREG-0002, the major risks from technetium-99 are from exposure of the gastrointestinal tract and kidney, although there is a small risk from total-body exposure. Using organ-specific risk estimators, these individual organ risks can be converted to total-body risk equivalent doses. Then, by using the total-body risk estimator of 135 cancer deaths per million person-rems, the estimated risk of cancer mortality due to technetium-99 releases from the nuclear fuel cycle is about 0.01 cancer fatality per RRY over the subsequent 100 to 1000 years.

In addition to the radon- and technetium-related potential health effects from the fuel cycle, other nuclides produced in the cycle, such as carbon-14, will contribute to population exposures. It is estimated that an additional 0.08 to 0.12 cancer death may occur per RRY (assuming that no cure for or prevention of cancer is ever developed) over the next 100 to 1000 years, respectively, from exposures to these other nuclides.

The latter exposures can also be compared 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 during the same time periods. From the above analysis, 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.

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 Table S-3 values 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.

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*Based on an annual average natural-background individual dose commitment of 100 mrems and a stabilized U.S. population of 300 million.

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

Council on Environmental Quality, "The Seventh Annual Report of the Council on Environmental Quality," Figures 11-27 and 11-28, pp. 238-239, September 1976.

Gotchy, R., testimony from "In the Matter of Duke Power Company (Perkins Nuclear Station)," U.S. Nuclear Regulatory Commission, Docket No. 50-488, filed April 17, 1978.

National Council on Radiation Protection and Measurements (NCRP), "Natural Background Radiation in the United States," NCRP Report No. 45, November 1975.

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 Recycle Plutonium in Mixed Oxide Fuel in Light-Water-Cooled Reactors," August 1976.

---, NUREG-0116 (Supplement 1 to WASH-1248), "Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle," October 1976.

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 three 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.

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)	Dosage (person-rems) Total body	Bone	Lung (bronchial epithelium)
Mining	4100	110	2800	2300
Milling and active tailings	1100	29	750	620
Total	5200	140	3600	2900

Table C-3 Population-dose commitments from unreclaimed open-pit mines for each year of operation of the model 1000-MWe LWR

		Population dose commitments (person-rems)		
Time span (years)	Radon-22 releases (Ci)	Total body	Bone	Lung (bronchial epithelium)
100	3,700	96	2,500	2,000
500	19,000	480	13,000	11,000
1,000	37,000	960	25,000	20,000

Table C-4 Population-dose commitments from stabilized-tailings piles for each year of operation of the model 1000-MWe LWR

		Population dose commitments (person-rems)		
Time span (years)	Radon-22 releases (Ci)	Total body	Bone	Lung (bronchial epithelium)
100	100	2.6	68	56
500	4,090	110	2,800	2,300
1,000	53,800	1,400	37,000	30,000

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 Millstone 3 facility are estimated on the basis of the description of the design and operation of the radwaste systems as contained in the applicant's FSAR and by using the calculative models and parameters described in NUREG-0017. These estimated effluent release values for normal operation, including 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 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 2010. 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 Tables D-1a, D-1b, and D-1c for Units 3, 1, and 2, respectively) along with the site meteorological considerations (summarized in Tables D-2a and D-2b for Unit 3, and Units 1 and 2, respectively) 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.

Two years of meteorological data were used in the calculation of concentrations of effluents. The calculation followed guidance given in RG 1.111, Revision 1. Onsite meteorological data collected from January 1981 through December 1982, with wind speed and direction measured at an elevation of 10 m and vertical temperature gradient measured between 10 and 43 m, were used as a measure of atmospheric stability. A straight line Gaussian dispersion model, corrected for effluent recirculation, was utilized for the routine gaseous release dispersion calculation.

The maximum relative concentration and deposition values are provided in Tables D-2a and D-2b.

The NRC staff estimates of the expected liquid releases (listed in Tables D-4a, D-4b, and D-4c for Units 3, 1, and 2, respectively), 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-6a, D-6b, and D-7. 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-6a, D-6b, and D-7.

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 Millstone - 3 facility are estimated for two populations: (1) all members of the general public within 80 km (50 miles) of Millstone 3 (Table D-7) and (2) the entire U.S. population (Table D-8). 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-0017, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWR-GALE Code)," April 1976.

---, 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-1a Calculated releases of radioactive materials in gaseous effluents from Millstone Unit 3 (Ci/yr)

	To Ventilation Vent (133 feet above grade)			To Unit 1 Stack (395 feet above grade)		
Nuclides	Reactor Building (interm)†	Auxiliary Building (cont)††	Turbine Building (cont)	Waste Gas System (cont)	Air Ejector System (cont)	Total
Ar-41	25	a	a	a	a	25
Kr-83m	a	a	a	a	a	a
Kr-85m	a	2	a	a	1	3
Kr-85	1	a	a	260	a	260
Kr-87	a	1	a	a	a	1
Kr-88	a	4	a	a	2	6
Kr-89	a	a	a	a	a	a
Xe-131m	1	a	a	a	a	1
Xe-133m	2	a	a	a	a	2
Xe-133	220	36	a	a	22	280
Xe-135m	a	a	a	a	a	a
Xe-135	2	5	a	a	3	10
Xe-137	a	a	a	a	a	a
Xe-138	a	1	a	a	a	1
			Total Noble Gases			560*
Mn-54	0.00082	0.018	b	0.0045	b	0.023
Fe-59	0.00028	0.006	b	0.0015	b	0.0078
Co-58	0.0028	0.06	b	0.015	b	0.078
Co-60	0.0013	0.027	b	0.007	b	0.035
Sr-89	0.000063	0.0013	b	0.00033	b	0.0017
Sr-90	0.000011	0.00024	b	0.00006	b	0.0031
Cs-134	0.00082	0.018	b	0.0045	b	0.023
Cs-137	0.0014	0.03	b	0.0075	b	0.039
			Total Particulates			0.21
I-131	0.0034	0.046	0.00033	a	0.029	0.079
I-133	0.0016	0.067	0.00046	a	0.042	0.11
H-3	a	1200	a	a	a	1200
C-14	1	a	a	7	a	8

†Interm = intermittent.

††Cont = continuous.

*Sum is truncated.

[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-1b Calculated releases of radioactive materials in gaseous effluents from Millstone Unit 1 (Ci/yr)

Nuclide	Containment Building	Turbine Building	Radwaste Building	Gland Seal	Air Ejector	Mech. Vacuum Pump	Total
Kr-83m	a	a	a	27	a	a	27
Kr-85m	6	68	a	48	380	a	500
Kr-85	a	a	a	a	150	a	150
Kr-87	6	130	a	160	a	a	300
Kr-88	6	230	a	160	83	a	480
Kr-89	a	a	a	710	a	a	710
Xe-131m	a	a	a	a	21	a	21
Xe-133m	a	a	a	2	a	a	2
Xe-133	130	250	10	65	1400	2300	4200
Xe-135m	92	650	a	20	a	a	760
Xe-135	68	630	45	180	a	350	1300
Xe-137	a	a	a	860	a	a	860
Xe-138	14	1400	a	660	a	a	2100
			Total Noble Gases				11,000
I-131	0.34	0.19	0.05	0.019	a	0.03	0.63
I-133	1.4	0.76	0.18	0.067	a	a	2.4
Cr-51	6(-4)[b]	1.3(-2)	9(-5)	c	c	c	1.4(-2)
Mn-54	6(-3)	6(-4)	3(-4)	c	c	c	6.9(-3)
Fe-59	8(-4)	5(-4)	1.5(-4)	c	c	c	1.4(-3)
Co-58	1.2(-3)	6(-4)	4.5(-5)	c	c	c	1.8(-3)
Co-60	2(-2)	2(-3)	9(-4)	c	c	c	2.3(-2)
Zn-65	4(-3)	2(-4)	1.5(-5)	c	c	c	4.2(-3)
Sr-89	1.8(-4)	6(-3)	4.5(-6)	c	c	c	6.2(-3)
Sr-90	1(-5)	2(-5)	3(-6)	c	c	c	3.3(-5)
Zr-95	8(-4)	1(-4)	5(-7)	c	c	c	9(-4)
Sb-124	4(-4)	3(-4)	5(7)	c	c	c	7(4)
Cs-134	8(-3)	3(-4)	4.5(-5)	c	c	3(-6)	8.3(-3)
Cs-136	6(-4)	5(-5)	4.5(-6)	c	c	2(-6)	6.6(-4)
Cs-137	1.1(-2)	6(-4)	9(-5)	c	c	1(-5)	1.2(-2)
Ba-140	8(-4)	1.1(-2)	1(-6)	c	c	1.1(-5)	1.2(-2)
Ce-141	2(-4)	6(-4)	2.6(-5)	c	c	c	8.3(-4)
			Total Particulates				9.3(2)
C-14	a	a	a	a	9.5	a	9.5
H-3	25	-	-	-	-	-	25
Ar-41	25	a	a	a	a	a	25

[a] Less than 1.0 Ci/yr for noble gases and carbon-14, less than 10^{-4} Ci/yr for iodine.

[b] Exponential notation; 6(-4) = 6 × 10^{-4}.

[c] Less than 1% of release for this nuclide.

Table D-1c Calculated releases of radioactive materials in gaseous effluents from Millstone Unit 2 (Ci/yr)

Nuclide	Off-Gas Storage Tanks	Reactor Contain ment	Auxiliary Bldg.	Turbine Bldg.	Blow-down Vent	Air Ejector Exhaust	Total
Kr-83m	a	a	a	a	a	a	a
Kr-85m	a	1	2	a	a	1	4
Kr-85	250	49	2	a	a	a	300
Kr-87	a	a	1	a	a	a	1
Kr-88	a	2	4	a	a	2	8
Kr-89	a	a	a	a	a	a	a
Xe-131m	a	38	2	a	a	1	41
Xe-133m	a	32	4	a	a	2	38
Xe-133	a	4700	290	a	a	180	5200
Xe-135m	a	a	a	a	a	a	a
Xe-135	a	9	6	a	a	4	19
Xe-137	a	a	a	a	a	a	a
Xe-138	a	a	a	a	a	a	a
			Total Noble Gases				5600
I-131	a	0.016	0.06	0.011	0.016	0.038	0.13
I-133	a	0.0032	0.07	0.011	0.016	0.044	0.13
Mn-54	4.5(-5)[b]	2.2(-4)	1.8(-4)	c	c	c	4.5(-4)
Fe-59	1.5(-5)	7.5(-5)	6(-5)	c	c	c	1.5(-4)
Co-58	1.5(-4)	7.5(-5)	6(-4)	c	c	c	1.5(-3)
Co-60	7(-5)	3.4(-4)	2.7(-4)	c	c	c	6.8(-4)
Sr-89	3.3(-6)	1.7(-5)	1.3(-5)	c	c	c	3.3(-5)
Sr-90	6(-7)	3(-6)	2.4(-6)	c	c	c	6(-6)
Cs-134	4.5(-5)	2.2(-4)	1.8(-4)	c	c	c	4.4(-4)
Cs-137	7.5(-5)	3.8(-4)	3(-4)	c	c	c	7.5(-4)
			Total Particulates				3.6(-3)
H-3	-	108	432	-	-	-	540
C-14	8	a	a	a	a	a	8
Ar-41	a	25	a	a	a	a	25

[a] Less than 1 Ci/yr for noble gases and carbon-14, less than 10^{-4} Ci/yr for iodine.

[b] Exponential notation; 4.5(-5) = 4.5 × 10^{-5}.

[c] Less than 1% of total for this nuclide.

Table D-2a Summary of atmospheric dispersion factors (χ/Q) and relative deposition values of maximum site boundary and receptor locations near Millstone Unit 3*

Location**	Source***	χ/Q (sec/m^3)	Relative Deposition (m^{-2})
Nearest effluent-control boundary (0.63 km SSW)	A	2.0×10^{-5}	9.2×10^{-8}
	B	2.0×10^{-9}	2.3×10^{-9}
	C	3.0×10^{-5}	1.4×10^{-7}
Nearest residence and garden (0.84 km ENE)	A	9.4×10^{-6}	7.4×10^{-8}
	B	3.5×10^{-9}	1.4×10^{-9}
	C	1.3×10^{-5}	1.0×10^{-7}
Nearest milk cow (3.2 km ENE)	A	6.1×10^{-7}	3.4×10^{-9}
	B	3.8×10^{-8}	6.9×10^{-10}
	C	1.3×10^{-5}	1.0×10^{-7}
Nearest milk goat (3.2 km ENE)	A	6.1×10^{-7}	3.4×10^{-9}
	B	3.8×10^{-8}	6.9×10^{-10}
	C	1.3×10^{-5}	1.0×10^{-7}
Nearest meat animal (3.2 km ENE)	A	6.1×10^{-7}	3.4×10^{-9}
	B	3.8×10^{-8}	6.9×10^{-10}
	C	1.3×10^{-5}	1.0×10^{-7}

*The values presented in this table are calculated 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 - Building ventilation vent, continuous release from auxiliary building and turbine building.

B - Unit 1 exhaust stack, continuous release from waste gas system and air ejector system.

C - Building ventilation vent, intermittent release from reactor building, 4 releases per year, 180 hours each.

Table D-2b Summary of atmospheric dispersion factors (χ/Q) and relative deposition values of maximum site boundary and receptor locations near Millstone Unit 3 from releases of Units 1 and 2

Location**	Source***	χ/Q (sec/m^3)	Relative Deposition (m^{-2})
Nearest effluent-control boundary (0.63 km SSW)	A B	3.0×10^{-5} 2.0×10^{-9}	9.2×10^{-8} 2.3×10^{-9}
Nearest residence and garden (0.84 km ENE)	A B	1.3×10^{-5} 3.5×10^{-9}	7.7×10^{-8} 1.4×10^{-9}
Nearest milk cow (3.2 km ENE)	A B	8.2×10^{-7} 3.8×10^{-8}	3.4×10^{-9} 6.9×10^{-10}
Nearest milk goat (3.2 km ENE)	A B	8.2×10^{-7} 3.8×10^{-8}	3.4×10^{-9} 6.9×10^{-10}
Nearest meat animal (3.2 km ENE)	A B	8.2×10^{-7} 3.8×10^{-8}	3.4×10^{-9} 6.9×10^{-10}

*The values presented in this table are calculated 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 - Building ventilation vent, continuous release from turbine building, auxiliary building and blowdown vent of Unit 2.

B - Unit 1 exhaust stack, continuous release from all Unit 1 releases and off-gas storage tanks, reactor containment and air ejector exhaust of Unit 2.

Table D-3 Nearest pathway locations used for maximally exposed individual dose commitments for the Millstone nuclear facility

Location	Sector	Distance (km)
Nearest effluent-control boundary*	SSW	0.63
Residence and garden**	ENE	0.84
Milk cow	ENE	3.2
Milk goat	ENE	3.2
Meat animal	ENE	3.2

*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-4a Calculated release of radioactive materials in liquid effluents from Millstone Unit 3

Nuclide	Ci/yr	Nuclide	Ci/yr
Corrosion and Activation Products		Fission Products (cont'd)	
Cr-51	3.3(-3)[a]	Te-127	8.9(-4)
Mn-54	1.1(-3)	Te-129m	2.8(-3)
Fe-55	6.2(-3)	Te-129	1.8(-3)
Fe-59	2.3(-3)	I-130	9(-5)
Co-58	4.4(-2)	Te-131m	2.4(-4)
Co-60	7.8(-3)	Te-131	4(-5)
Zr-95	1.6(-4)	I-131	1.6(-1)
Nb-95	1.9(-4)	Te-132	6.4(-3)
Np-239	2.1(-4)	I-132	7.3(-3)
	I-133	I-133	2.6(-2)
Fission Products		I-134	1.5(-4)
		Cs-134	9.6(-2)
Br-83	4(-5)	I-135	4.5(-3)
Rb-86	1.1(-4)	Cs-136	1.2(-2)
Rb-88	2.1(-4)	Cs-137	7.2(-2)
Sr-89	8.6(-4)	Ba-137m	6.7(-2)
Sr-90	4(-5)	Ba-140	2(-4)
Y-90	4(-5)	La-140	2.2(-4)
Sr-91	2(-5)	Ce-141	1.3(-4)
Y-91m	1(-5)	Pr-143	5(-5)
Y-91	1.8(-4)	Ce-144	1.2(-4)
Mo-99	1.7(-2)	Pr-144	1.2(-4)
Tc-99m	1.6(-2)		
Ru-103	1(-4)	All Others[b]	1(-5)
Ru-103m	1(-4)		
Ru-106	4(-5)	Total (except H-3)	5.6(-1)
Rh-106	4(-5)	H-3	250
Te-125m	7(-5)		
Te-127m	8.7(-4)		

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[a] Exponential notation: 2.6(-4) = 2.6 x 10^{-4}.

[b] Nuclides whose release rates are less than 10^{-5} Ci/yr are not listed individually, but are included in "All Others."

Table D-4b Calculated release of radioactive materials in liquid effluents from Millstone Unit 1

Nuclide	Ci/yr	Nuclide	Ci/yr
Corrosion & Activation Products		Fission Products (cont'd)	
Na-24	7.1(-3)[a]	Tc-101	3(-5)
P-32	2.9(-4)	Ru-103	1.7(-4)
Cr-51	7.3(-3)	Rh-103m	3(-5)
Mn-54	1.1(-3)	Tc-104	7(-5)
Mn-56	7.5(-3)	Ru-105	6.1(-4)
Fe-55	1.6(-3)	Rh-105m	6.1(-4)
Fe-59	4(-5)	Rh-105	1.2(-4)
Co-58	4.3(-3)	Ru-106	2.4(-3)
Co-60	9.3(-3)	Ag-110m	4.4(-4)
Ni-65	4(-5)	Te-129m	6(-5)
Cu-64	2.2(-2)	Te-129	3(-5)
Zn-65	3(-4)	Te-131m	1.1(-4)
Zn-69m	1.5(-3)	Te-131	2(-5)
Zn-69	1.6(-3)	I-131	5.5(-2)
Zr-95	1.4(-3)	Te-132	1(-5)
Nb-95	2(-3)	I-132	7.2(-3)
W-187	2.8(-4)	I-133	5(-2)
Np-239	8.4(-3)	I-134	2.4(-3)
		Cs-134	1.3(-2)
Fission Products		I-135	2.1(-2)
		Cs-136	2.4(-4)
Br-83	7.8(-4)	Cs-137	2.5(-2)
Br-84	4(-5)	Ba-137m	8.4(-4)
Rb-89	2(-5)	Cs-138	5.9(-4)
Sr-89	1.5(-4)	Ba-139	5.3(-4)
Sr-91	2.5(-3)	Ba-140	5.7(-4)
Y-91m	1.5(-3)	La-140	1(-4)
Y-91	7(-5)	La-141	1.3(-4)
Sr-92	1.6(-3)	Ce-141	4(-5)
Y-92	3.2(-3)	La-142	3.6(-4)
Y-93	2.5(-3)	Ce-143	3(-5)
Nb-98	8(-5)	Pr-143	6(-5)
Mo-99	2.5(-3)	Ce-144	5.2(-3)
Tc-99m	9.6(-3)	All Others[b]	7(-5)
		Total, (except H-3)	2.8(-1)
		H-3	2.5(+1)

[a] Exponential notation; 7.1(-3) = 7.1 × 10^{-3}.

[b] Nuclides not specifically identified above are calculated to be less than 10^{-5} Ci/yr and are included in the category "All Others."

Table D-4c Calculated release of radioactive materials in liquid effluents from Millstone Unit 2

Nuclide	Ci/yr	Nuclide	Ci/yr
Corrosion & Activation Products		Fission Products (cont'd)	
Cr-51	2.0(-2)[a]	I-131	6.4(-1)
Mn-54	5.6(-3)	Te-132	1.6(-1)
Fe-55	1.9(-2)	I-132	6.1(-2)
Fe-59	1.3(-2)	I-133	4.2(-1)
Co-58	1.9(-1)	I-134	8.2(-3)
Co-60	3.0(-2)	Cs-134	2.1 (0)
Zr-95	1.4(-3)	I-135	1.3(-1)
Nb-95	2.0(-3)	Cs-136	7.7(-1)
Np-239	8.4(-3)	Cs-137	1.5 (0)
		Ba-137m	1.2 (0)
Fission Products		Ba-140	2.1(-3)
		La-140	1.1(-3)
Br-83	1.8(-3)	Ce-141	8.8(-4)
Br-84	3.0(-4)	Ce-143	1.1(-4)
Rb-86	5.5(-3)	Pr-143	4.3(-4)
Rb-88	1.4(-2)	Ce-144	5.7(-3)
Sr-89	4.5(-3)	Pr-144	9(-5)
Sr-90	1.0(-4)		
Y-90	2.0(-5)	All Others[b]	1(-5)
Sr-91	1.1(-3)	Total (except H-3)	8.1 (0)
Y-91m	2.1(-4)		
Y-91	6.9(-4)	H-3	5.3(+2)
Y-93	6(-5)		
Zr-95	8.9(-4)		
Nb-95	8.7(-4)		
Mo-99	6.0(-1)		
Tc-99m	1.5(-1)		
Ru-103	6.0(-4)		
Rh-103m	1.0(-4)		
Ru-106	2.5(-3)		
Rh-106	2(-5)		
Ag-110m	4.4(-4)		
Te-125m	2.4(-4)		
Te-127m	2.4(-3)		
Te-127	2.0(-3)		
Te-129m	1.4(-2)		
Te-129	2.5(-3)		
I-130	1.9(-3)		
Te-131m	1.1(-2)		
Te-131	4.1(-4)		

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[a] Exponential notation: 2.0(-2) = 2.0 × 10^{-2}.

[b] Nuclides not specifically identified above are calculated to be less than 10^{-5} Ci/yr and are included in the category "All Others."

Table D-5 Summary of hydrologic transport and dispersion for liquid releases from the Millstone nuclear facility*

Location	Transit Time (hours)	Dilution Factor
Nearest sport-fishing location (discharge area)**	0	3
Nearest shoreline (bank of Long Island Sound near discharge area)	0	7

*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.

**Assumed for purposes of an upper-limit estimate; detailed information not available.

Table D-6a Annual dose commitments to a maximally exposed individual from operation of Millstone Unit 3

Location	Pathway	Doses (mrems/yr, except as noted)			
		Noble Gases in Gaseous Effluents			
		Total Body	Skin	Gamma Air Dose (mrads/yr)	Beta Air Dose (mrads/yr)
Nearest* site boundary (0.63 km SSW)	Direct radiation from plume	0.25	0.35	0.35	0.35
		Iodine and Particulates in Gaseous Effluents**			
		Total Body	Organ		
Nearest*** site boundary (0.63 km SSW)	Ground deposition Inhalation	3.6 (T) 0.96 (T)	3.6 (T) (thyroid) 1.5 (T) (thyroid)		
Nearest residence and garden (0.84 km ENE)	Ground deposition Inhalation Vegetable consumption	2.9 (C) 0.41 (C) 2.4 (C)	2.9 (C) (liver) 0.42 (C) (liver) 4.5 (C) (liver)		
Nearest milk cow (3.2 km ENE)	Ground deposition Inhalation Vegetable consumption Cow milk consumption	0.14 (I) a (I) a (I) a (I)	0.14 (I) (thyroid) a (I) (thyroid) a (I) (thyroid) 2.2 (I) (thyroid)		
Nearest milk goat (3.2 km ENE)	Ground deposition Inhalation Vegetable consumption Goat milk consumption	0.14 (I) a (I) a (I) 0.19 (I)	0.14 (I) (thyroid) a (I) (thyroid) a (I) (thyroid) 2.6 (I) (thyroid)		
Nearest meat animal (3.2 km ENE)	Meat consumption	a (C)	a (C) (thyroid)		
		Liquid Effluents**			
		Total Body	Organ		
Nearest fish at plant-discharge area	Fish consumption	a (A)	a (A) (thyroid)		
Nearest shore access near plantdischarge area	Shoreline recreation	a (A)	a (A) (thyroid)		

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[a] Less than 0.1 mrem/year.

*"Nearest" refers to that site boundary location where the highest radiation doses as a result of gaseous effluents have been estimated to occur.

**Doses are for the age group and organ that results in the highest cumulative 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.

Table D-6b Annual dose commitments to a maximally exposed individual from operation of Millstone Units 1, 2, and 3

Location	Pathway	Doses (mrems/yr, except as noted)			
		Noble Gases in Gaseous Effluents			
		Total Body	Skin	Gamma Air Dose (mrads/yr)	Beta Air Dose (mrads/yr)
Nearest* site boundary (0.63 km SSW)	Direct radiation from plume	0.36	0.61	0.53	0.69
		Iodine and Particulates in Gaseous Effluents**			
		Total Body	Organ		
Nearest*** site boundary (0.63 km SSW)	Ground deposition	3.7 (T)	3.7 (T) (thyroid)		
	Inhalation	1.5 (T)	3.5 (T) (thyroid)		
Nearest residence and garden (0.84 km ENE)	Ground deposition	3.0 (C)	3.0 (C) (liver)		
	Inhalation	0.61 (C)	0.62 (C) (liver)		
	Vegetable consumption	3.1 (C)	5.2 (C) (liver)		
Nearest milk cow (3.2 km ENE)	Ground deposition	0.16 (I)	0.16 (I) (thyroid)		
	Inhalation	a (I)	0.1 (I) (thyroid)		
	Vegetable consumption	a (I)	a (I) (thyroid)		
	Cow milk consumption	0.10 (I)	11 (I) (thyroid)		
Nearest milk goat (3.2 km ENE)	Ground deposition	0.16 (I)	0.16 (I) (thyroid)		
	Inhalation	a (I)	0.1 (I) (thyroid)		
	Vegetable consumption	a (I)	a (I) (thyroid)		
	Goat milk consumption	0.28 (I)	13 (I) (thyroid)		
Nearest meat animal (3.2 km ENE)	Meat consumption	a (C)	0.1 (C) (thyroid)		
		Liquid Effluents**			
		Total Body	Organ		
Nearest fish at plant-discharge area	Fish consumption	a (A)	a (A) (thyroid)		
Nearest shore access near plantdischarge area	Shoreline recreation	a (A)	a (A) (thyroid)		

[a] Less than 0.1 mrem/year.

*"Nearest" refers to that site boundary location where the highest radiation doses as a result of gaseous effluents have been estimated to occur.

**Doses are for the age group and organ that results in the highest cumulative 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.

Table D-7 Calculated Appendix I dose commitments to a maximally exposed individual and to the population from operation of Millstone Unit 3

	Annual Dose per Reactor Unit	
	Individual	
	Appendix I Design Objectives*	Calculated Doses**
Liquid effluents		
Dose to total body from all pathways	3 mrems	a
Dose to any organ from all pathways	10 mrems	a (thyroid)
Noble-gas effluents (at site boundary)		
Gamma dose in air	10 mrads	0.35 mrads
Beta dose in air	20 mrads	0.35 mrads
Dose to total body of an individual	5 mrems	0.25 mrems
Dose to skin of an individual	15 mrems	0.35 mrems
Radioiodines and particulates***		
Dose to any organ from all pathways	15 mrems	7.8 mrems (liver)

	Population Dose Within 80 km, person-rems	
	Total Body	Thyroid
Natural-background radiation†	370,000	-
Liquid effluents	0.44	1.3
Noble-gas effluents	0.11	0.11
Radioiodine and particulates	5.6	9.7

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*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 Connecticut of 110 mrems/yr, and year 2010 projected population of 3,300,000.

[a] Less than 0.1 mrem/year.

Table D-8 Annual total-body population dose commitments, year 2000 (all units)

Category	U.S. Population Dose Commitment (person-rems/yr)
Natural background radiation*	26,000,000*
Millstone 3 operation	
Plant workers	1,500
General public:	
Liquid effluents**	7.1
Gaseous effluents	55
Transportation of fuel and waste	9

*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

MILLSTONE 3 ACCIDENT SEQUENCES AND RELEASE CATEGORIES USED IN CONSEQUENCE ANALYSIS

APPENDIX E
MILLSTONE 3 ACCIDENT SEQUENCES AND RELEASE CATEGORIES USED IN CONSEQUENCE ANALYSIS

The staff requested Brookhaven National Laboratory (BNL) (Katib-Rahbar et al., 1983) to help develop specifications of atmospheric release of radionuclides from severe accidents at Millstone 3 based on the applicant's "Millstone Unit 3 Probabilistic Safety Study" (Northeast Utilities, 1983). The specifications included (1) identification of core-melt-accident sequences leading to atmospheric release initiated by internal causes, fires, and earthquakes; (2) probabilities per reactor-year of the sequences; and (3) quantities and forms of radionuclides (source terms) and the other parameters necessary for appropriate characterization of atmospheric release from the sequences.

The staff made recommendations to BNL regarding the method of estimating the source terms. The NRC and the nuclear industry have funded in-depth research on the release and behavior of fission products since the publication of the Reactor Safety Study (RSS) in 1975 (NUREG-75/014). Improved methods for assessing fission product source terms are being developed and are receiving extensive peer review. However, the staff judged that applying evolving methodologies for assessment of source terms in plant licensing before they are thoroughly and carefully appraised would be premature. Therefore, the staff requested that BNL use the RSS methodology for fission product release from the damaged fuel, primary system holdup, credit for washout by containment sprays, and fallout, plateout, and transport of radionuclides in the containment leading to atmospheric release. This methodology is described 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 fuel while it first heats to melting and becomes molten. High gas flows 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 molded 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 the containment building is allowed in the primary system. Thus, (except for containment bypass sequences) all the fission products released during the gap and melt release phases are assumed to enter the containment building.

In the RSS methodology, the fission product transport within the containment building volumes is predicted using the CORRAL-II (RSS) code. This code is used in conjunction with the fission product release model, containment spray model, and the MARCH (RSS) code.

As stated earlier, in the source term assessment made by BNL for use in the Millstone 3 Draft Environmental Statement, only the RSS methodology was used. Use of the RSS methodology for Millstone 3 may have resulted in overestimates of source terms for some accident sequences and underestimates of source terms for others as discussed in the section entitled "Quantity and Chemical Form of Radioactivity Released" in Section 5.9.4.5(7). 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 RSS guidelines, BNL modified the applicant's 13 release categories and added another. Of these 14 release categories, only 8 were found to be significant with respect to risk. Characteristics of the release categories are shown in Table 5.15, and their likelihoods (annual probabilities) are shown in Table 5.16.

When reviewing 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. A description of the methodology and results follows.

In the Millstone Probabilistic Safety Study (M-PSS), each core-melt accident sequence is assigned to one of the plant damage states described in Tables E.1 and E.2. Summation over all of the frequencies of core-melt accidents associated with a given plant damage state yields the annual frequency of the damage state listed in Tables E.3 and E.4. For internal* events the original M-PSS plant damage state frequencies are also included in Table E.3 for reference. The frequencies in Table E.3 are based on the Lawrence Livermore National Laboratory (LLNL, 1984) review. Note that in the M-PSS, 27 plant damage state frequencies were identified, whereas in the LLNL review, only 17 plant damage state frequencies were given. The LLNL review eliminated 12 damage states (namely, AEC', AE, ALC", AL, SEC', S'E, SLC", SL, V2E, V2LC', V2LC" and V2L) from further consideration because of low probability ($<10^{-7}$) but also added

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*Refers to all initiating events except seismic events.

additional damage states, namely, S'EC and TE with and without the auxiliary anticipated transient without scram mitigating system actuation circuitry (AMSAC).

The plant damage states classify events according to three parameters:

(1) initiating event

A	large break loss-of-coolant accidents (LOCAs)
S	small-break LOCAs
S'	incore instrument tube LOCA
T	transients
V2	steam generator tube rupture (SGTR)
V3	seismically induced AE combined with containment bypass
V	interfacing systems LOCA

(2) timing of core melt

E	failure of emergency core cooling injection (ECCI)
L	failure of ECC recirculation

(3) status of containment heat removal (CHR)

	complete loss of containment sprays (CS)
$\overline{C}'$	loss of recirculation CS
C"	loss of quench CS
C	all spray systems available

In the M-PSS, the plant states identified in Tables E.1 and E.2 were related to potential containment building failure modes by using containment event trees. It was considered unnecessary to analyze each individual plant state because of common characteristics relative to primary system response, containment response, and source term. The primary system response characteristics were grouped using accident sequence classes (A-G in the M-PSS). Accident sequences were classified in the M-PSS according to

(1) the initiating event
(2) time of onset of fuel melt
(3) reactor coolant system (RCS) conditions at time of vessel failure, particularly RCS pressure

Five of the sequence classes (A-E) required further analysis to characterize the containment response. Accident classes F (interfacing system LOCA) and G (ruptured steam generator tube) bypass the containment and hence were allocated directly to an appropriate release path and fission produce source term.

Characterization of containment response for the five accident classes (A-E) was required for possible combinations of quench spray system and recirculation spray system operation. These quench and recirculation spray system combinations are

(1) both quench sprays and recirculations sprays on
(2) both sprays off

(3) quench sprays on, recirculation sprays off
(4) recirculation sprays on, quench sprays off

This characterization (for internal events) by accident sequence and containment response for 5 of the accident classes defines 20 distinct accident groups or categories. Again, because of common characteristics, it was not considered necessary to assess all of the possibilities and hence only 10 containment response classes were quantified using containment event trees in the M-PSS. These containment response classes are defined in Table E.5.

Tables E.6 and E.7 summarize the containment response classes with the corresponding plant damage states and their associated mean frequencies for internal and external events, respectively. Therefore, these containment response classes can be related to the radiological release categories to form the containment matrices for both internal and external events.

The quantification of the M-PSS containment event trees was a significant task, and it was necessary to use a computer code, ARBRE, to group the various path probabilities into the 13 release categories (Northeast Utilities, 1983). Table E.8 lists release categories given the plant damage state, with the plant damage states defined earlier in Tables E.3 and E.4. A steam explosion release category M2B has been added for both internal and external events.

Table 5.15 clearly indicates the dependence of the radiological release characteristics on the containment response class. These values are equally applicable to the external initiating events.

Release categories M3, M5, M8, M9, M10, and M11 were determined to have a negligible contribution to risk. The small annual probability of M5 was added to M6. M12 was carried in the risk calculations only because its probability was high compared with the total probability. The relatively small probabilities for M8, M9, and M10 were added to that of M12.

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 (peak ground acceleration equal to or in excess of 0.5g*), and the other part was associated with the same release category initiated by low to moderately severe earthquakes (peak ground acceleration less than 0.5g). 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 5.16.

The purpose of such a breakdown was to aid in making appropriate assumptions regarding offsite emergency response in the consequence analysis. It was the judgment of the staff that earthquakes resulting in peak ground acceleration equal to or greater than about 0.5g would be a severity of Modified Mercalli (MM)

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*g stands for acceleration due to gravity and is numerically about 32 feet per second per second.

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 J 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 5.16. Further, the mean probability of the release category is not necessarily 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 a discussion of uncertainties resulting from this use, provides a reasonable risk perspective. For a discussion of uncertainties see Section 5.9.4.5(7).

References

Katib-Rahbar, M., H. Ludewig, and W. T. Pratt, "Preliminary Review and Evaluation of the Millstone-3 Probabilistic Safety Study," Brookhaven National Laboratory, informal report, December 1983.

Lawrence Livermore National Laboratory, "A Review of the Millstone-3 Probabilistic Safety Study," Incomplete Preliminary Draft, January 25, 1984.

Northeast Utilities, "Millstone Unit 3 Probabilistic Safety Study," August 1983.

U.S. Nuclear Regulatory Commission, NUREG/75-014 (formerly WASH-1400), "Reactor Safety Study, An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants," October 1975.

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*The lack of actual recording associated with this intensity made the choice of 0.5g imprecise. A sensitivity analysis performed with a range of values of peak ground acceleration such as 0.4g to 0.6g would have been more appropriate. However, it was the staff's judgment that a breakdown of probabilities of seismically induced release categories using several values from the range 0.4g to 0.6g of peak ground acceleration would not have resulted in probability sets very different from those obtained by using 0.5g.

Table E.1 Notation and definitions for plant states (internal)

Symbol	Description
AEC	Large LOCA, early melt
AEC'	Large LOCA, early melt, failure of recirculation spray
AE	Large LOCA, early melt, no containment cooling
ALC	Large LOCA, late melt
ALC'	Large LOCA, late melt, failure of recirculation spray
ALC"	Large LOCA, late melt, failure of quench spray
AL	Large LOCA, late melt, no containment cooling
SEC	Small LOCA, early melt
SEC'	Small LOCA, early melt, failure of recirculation spray
SE	Small LOCA, early melt, no containment cooling
S'E	Incore instrument tube LOCA, early melt, no containment cooling
S'EC	Incore instrument tube LOCA, early melt
SLC	Small LOCA, late melt
SLC'	Small LOCA, late melt, failure of recirculation spray
SLC"	Small LOCA, late melt, no failure of quench spray
SL	Small LOCA, late melt, no containment cooling
S'L	Incore instrument tube LOCA, late melt, no containment cooling
TEC	Transient, early melt
TEC'	Transient, early melt, failure of recirculation spray
TE	Transient, early melt, no containment cooling
V2EC	Steam generator tube rupture (SGTR), steam leak, early melt
V2EC'	SGTR, steam leak, early melt, failure of recirculation spray
V2E	SGTR, steam leak, early melt, no containment cooling
V2LC	SGTR, steam leak, late melt
V2LC'	SGTR, steam leak, late melt, failure of recirculation spray
V2LC"	SGTR, steam leak, late melt, failure of quench spray
V2L	SGTR, steam leak, late melt, no containment cooling
V	Interfacing systems LOCA

Table E.2 Notation and definitions for plant damage states with seismic initiator (external)

Symbol	Description
AE	Large LOCA, early melt, no containment cooling
SE	Small LOCA, early melt, no containment cooling
TE	Transient, early melt, no containment cooling
AL	Large LOCA, late melt, no containment cooling
SL1	Consequential LOCA due to opening power-operated relief valves to perform feed and bleed subsequent to a seismically induced loss of offsite power
SL2	Late core melt following an S initiator (small-break LOCA)
AEC	Large LOCA, early melt
SEC	Small LOCA, early melt
TEC	Transient, early melt
AEC'	Large LOCA, early melt, failure of recirculation spray
SEC'	Small LOCA, early melt, failure of recirculation spray
TEC'	Transient, early melt, failure of recirculation spray
ALC	Large LOCA, late melt
SL1C	Same as SL1 except for full containment heat removal system (CHRS) operation
SL2C	Same as SL2 except for full CHRS operation
ALC'	Large LOCA, late melt, failure of recirculation spray
SL1C'	Same as SL1C except for failure of recirculation spray
SL2C'	Same as SL2C except for failure of recirculation spray
V3	AE combined with containment bypass

Table E.3 Plant damage state frequencies for internal events (per reactor-year)

Symbol	M-PSS-3	Staff
AEC	1.92E-6*	1E-6
AEC'	4.17E-9	**
AE	2.68E-9	**
ALC	5.44E-6	4E-6
ALC'	4.88E-7	3E-7
ALC"	3.42E-9	**
AL	3.36E-10	**
SEC	1.12E-6	6E-5
SEC'	2.76E-9	**
SE	1.17E-7	2E-5
S'EC	-	9E-7
S'E	1.83E-9	**
SLC	9.81E-6	2E-5
SLC'	4.79E-7	4E-7
SLC"	5.77E-8	**
SL	2.73E-9	**
S'L	3.35E-10	2E-7
TEC	1.81E-5	2E-5
TEC'	3.46E-7	6E-7
TE with AMSAC***	5.31E-6	6E-6
TE without AMSAC	-	3E-5
V2EC	1.11E-7	4E-6
V2EC'	1.03E-9	3E-7
V2E	1.29E-8	**
V2LC	2.76E-9	2E-7
V2LC'	1.49E-10	**
V2LC"	1.77E-11	**
V2L	8.40E-13	**
V	1.90E-6	4E-7
Total	4.35E-5	1.38E-4 with AMSAC

*1.92E-6 = 1.92 × 10^{-6}.

**Indicates frequency $<10^{-7}$.

***Auxiliary ATWS mitigating system actuation circuitry.

Table E.4 Plant damage state frequencies for external events (per reactor-year)

Plant Damage State	M-PSS-3	Staff Calculation
AEC	1.06E-9*	**
AEC'	3.24E-10	**
AE	1.22E-6	5E-7
ALC	2.53E-9	**
ALC'	1.57E-7	**
AL	1.62E-9	**
SEC	2.97E-7	**
SEC'	1.04E-7	**
SE	7.38E-6	6E-6
SLC	1.25E-8	**
SLC'	3.03E-7	**
SL	5.16E-9	**
TEC	4.69E-10	**
TEC'	6.90E-11	**
TE	7.80E-6	**
V3	7.14E-8	1E-7
Total	1.73E-5	6.6E-6

*1.06E-9 = 1.06 × 10^{-9}.

**Indicates frequency <1 × 10^{-7}.

Table E.5 Containment response class

Class	Dominant Sequence	Reference Definitions
1	AE	Initiating event is typically a large-break LOCA without safety injection and without minimum containment safeguards operating throughout the transient.
2	SE	Same as the AE sequence except that the initiating event is typically a small-break LOCA or transient event. Note that the containment sprays do not operate.
3	AL	Same as the AE sequence except that safety injection is initiated but operates only until switchover to recirculation is attempted, at which time it becomes inoperative for the remainder of the transient.
4	TE	The initiating event is typically a transient in which all power is lost. There would, therefore, be no safety injection and no containment safeguards initiation at any time during the transient.
5	SL	Same as the AL sequence except that the initiating event is typically a small-break LOCA or transient event. Note that the containment sprays are actuated but do not deliver water to the spray headers.
6	TEC	Same as the TE sequence except that all containment ment heat removal systems are available.
7	TEC'	Same as the TE sequence (Class 4) except that ac power is available and the containment quench spray system is functioning.
8	SEC'	Same as the SE sequence (Class 2) except that the containment quench spray system is functioning.
9	TEC"	Same as the TE sequence (Class 4) except that ac power is available and the recirculation spray system is functional.
10	S'L	Same as the SL sequency (Class 5) except that rupture is an incore instrumentation tube rupture.

Table E.6 Containment class mean frequencies for internal events (per reactor-year)

Containment Class	Plant Damage States	Main Frequency (yr^{-1})
1	AE	2.68E-3*
2	SE	2E-5
3	AL	3.36E-10
4	TE	6E-6 with AMSAC**
5	SL	3E-5 without AMSAC
6	AEC, ALC, SEC, SLC, TEC, S'EC	1.06E-4
7	TEC', SLC'	6.0E-7
8	AEC', ALC', SEC'	3.07E-7
9	ALC", SLC"	6.11E-8
10	S'E, S'L	2.02E-7
	V2EC, V2EC', V2E, V2LC, V2LC', V2LC", V2L	4.51E-6
	V	4.0E-7

*2.68E-3 = 2.68×10^{-3}.
**Auxiliary ATWS mitigating system actuation circuitry.

Table E.7 Containment class mean frequencies for the external events

Containment Class	Plant Damage States	Mean Frequency (yr^{-1})
1	AE	5E-7*
2	SE	6E-6
3	AL	**
4	TE	**
5	SL	**
6	AEC,AL,SEC,SLC,TEC	**
7	TEC',SLC	**
8	AEC',ALC',SEC,	**
	V3	1.0E-7

*5E-7 = 5×10^{-7}.
**Indicates frequency $<1 \times 10^{-7}$.

Table E.8 Notation and definitions for release categories

Release Category	Description
M1A	Containment bypass, V-sequence
M1B	Containment bypass, steam generator tube rupture
M2A	Early failure/early melt, no sprays
M2B	Steam explosion failure
M3	Early failure/late melt, no sprays
M4	Containment isolation failure
M5	Intermediate failure/late melt, no sprays
M6	Intermediate failure/early melt, no sprays
M7	Late failure, no sprays
M8	Intermediate failure with sprays
M9	Late failure with sprays
M10	Basemat failure, no sprays
M11	Basemat failure with sprays
M12	No containment failure

APPENDIX F
CONSEQUENCE MODELING CONSIDERATIONS

APPENDIX F
CONSEQUENCE MODELING CONSIDERATIONS

F.1 Evacuation Model

"Evacuation," used in the context of offsite emergency response in the event of a 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, now 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 F-2) and acute radiation sickness that would require hospitalization. Evacuation may also reduce the long-term radiological health impacts of accidents. 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 (Sandia, 1978) 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 of 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 under way.

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*Assumed to be a 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 network. 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 evacuees' radiological exposure is due to their component motion along the radial downwind direction (over a component path length that 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; that is, 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 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 with 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.

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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.

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.

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 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 be evacuated and temporarily relocated. However, if the duration of release were to exceed 3 hours, the cost of evacuation is based on the assumption that all people within the entire plume exposure pathway EPZ would be evacuated and temporarily relocated. 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.

F.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 effectiveness of different classes of medical treatment (Elliot, 1982). Estimates of the early fatility risks using the dose-mortality relationship that are based on the supportive treatment alternative are presented in the text of Section 5.9.4.5 of the main body of this report. 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 on 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. The 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 Millstone 3 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.

F.3 References

Elliot, D.A., Task 5 letter report from D. A. Elliot of Andrulis Research Corp. to A. Chu, NRC, 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 G

STATE OF CONNECTICUT NPDES PERMIT

STATE OF CONNECTICUT
DEPARTMENT OF ENVIRONMENTAL PROTECTION

WATER COMPLIANCE UNIT
DIVISION OF ENVIRONMENTAL QUALITY
CONNECTICUT DEPARTMENT OF ENVIRONMENTAL PROTECTION
STATE OFFICE BUILDING
HARTFORD, CONNECTICUT 06115

NPDES PERMIT

November 8, 1983

Northeast Nuclear Energy Company
P. O. Box 270
Hartford, Connecticut 06101

Attention: Mr. W. G. Counsil
Vice President

Re: DEP/WPC-152-001
Town of Waterford
Long Island Sound Watershed

Gentlemen:

This order modification is authorized to be issued by Chapter 446k, Connecticut General Statutes and Section 402(b), Federal Water Pollution Control Act, as amended, 33 USC 1251, <u>et</u>. <u>seq</u>., and pursuant to an approval dated September 26, 1973, by the Administrator of the United States Environmental Protection Agency for the State of Connecticut to administer an N.P.D.E.S. permit program.

The Commissioner of Environmental Protection (hereinafter "the Commissioner") has determined that the effluent limitations which would require the use of cooling systems at the Millstone Nuclear Power Station, Units 1, 2 and 3 other than the once-through system proposed by the applicant for the control of the thermal component of the applicant's discharge are more stringent than necessary to assure the protection and propagation of a balanced indigenous population of shellfish, fish, and wildlife in and on the receiving waters. In view of this finding, the Commissioner has herein established alternative and less stringent effluent limitations in accordance with Section 316(a) of the Clean Water Act.

However, the Commissioner has also determined that additional evidence based upon actual operating experience of Millstone Point Nuclear Power Stations Units 1, 2 and 3 would be desirable in order to corroborate the Commissioner's findings. The Commissioner expressly reserves the right to impose more stringent effluent limitations with respect to the thermal component of the Company's discharge pursuant to Section 22a-430 of Chapter 446k, Connecticut General Statutes should further investigation of the effect of the Company's discharge fail to corroborate the Commissioner's determination that more stringent effluent limitations are not necessary to assure the protection and propagation of a balanced indigenous population of the shellfish, fish and wildlife in and on the receiving waters.

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The Commissioner finds that insufficient data is presently available to review the applicable factors required to be considered under Section 316(b) of the Federal Act in order to determine the best available technology for minimizing the adverse environmental impact of the permittee's existing and proposed cooling water intake structures. Such data will be generated by the studies to be conducted pursuant to paragraphs 5, 12, and 14 of this order and permit. The Commissioner further finds in this instance that no such determination is necessary at this time to carry out the purposes of the Federal Act pursuant to Section 402(a)(1) thereof. The Director will make such a determination for the existing intake structures after the submission of the report required in paragraph 14. In making his determination as to best technology available and the need for implementation, the Director shall consider the studies conducted in accordance with paragraphs 5 herein together with such other information as he deems competent, relevant and material.

The Company should take cognizance of the fact that additional evidence may result in the imposition of more stringent effluent limitations requiring the potential utilization of a cooling system other than one proposed. Accordingly, the company should take this potential into consideration in their design wherever feasible.

The Commissioner hereby finds that The Northeast Nuclear Energy Company is maintaining a facility known as Millstone Nuclear Power Station, described in the above-referenced application which reasonably can be expected to create a source of pollution to the waters of the state under the provisions of Chapter 446k of the Connecticut General Statutes as amended. The Commissioner, acting under Section 22a-432 hereby orders Northeast Nuclear Energy Company, Millstone Nuclear Power Station, to take such action as is necessary to:

1) Insure that all wastewaters generated by the activities of The Northeast Nuclear Energy Company, Millstone Nuclear Power Station Unit Nos. 1 and 2, described in the above-referenced application are collected, treated and discharged in accordance with associated engineering documents, correspondence and other data submitted to comply or obtained to verify compliance with the permits issued by the Director of Water compliance on May 24, 1974 and/or discharged in accordance with this order.

2) Insure that all wastewaters which will be generated by the construction and/or operating activities carried on at the Millstone Nuclear Power Station Unit No. 3 described in the above referenced application will be collected, treated and discharged in accordance with plans and specifications submitted for the approval of the Commissioner together with associated engineering documents, correspondence and other data submitted to comply or obtained to verify compliance with this order.

3) Insure that all discharges described in this order (after giving credit for condition of intake water, where applicable) shall not exceed and shall otherwise conform to the specific terms and general conditions specified herein. (Refer to Individual Discharge Serial Numbers).

4) Not discharge any new pollutant not authorized by this order which has or may have an adverse impact on the receiving waters.

5) The permittee shall conduct or continue to conduct biological studies of the supplying and receiving waters, entrainment studies, and intake impingement monitoring. The studies shall include studies of intertidal and subtidal benthic communities, finfish communities, and entrained plankton and shall include detailed studies of lobster populations and winter flounder populations.

6) Monitor and record the following for the purpose of reporting quality and quantity of each discharge according to the following schedule: (Refer to Individual Discharge Serial Numbers).

7) Not bypass the treatment facilities or any part thereof at any time. If any part of the waste treatment facilties becomes inoperable at any time, the Water Compliance Unit shall be notified immediately. A written report shall follow, giving the cause of the problem, duration and corrective measures taken.

8) Dispose of screenings, sludges and other solids or oils and other liquid chemicals at locations approved in accordance with the provisions of Chapter 446k and/or Chapter 361a of the Connecticut General Statutes or to waste haulers licensed under Chapter 446K of the Connecticut General Statutes.

9) Provide an alternate power source adequate to operate the treatment facilities and/or such other means as may be appropriate to insure that no discharge of untreated or partially treated wastewater will occur during a failure of the primary power source.

10) On or before July 31, 1980 verify to the Commissioner that compliance with paragragh 1 is being achieved and that the provision of paragraphs 2, 3, 4, 5, 6, 7, 8, and 9 will be complied with.

11) On or before July 31, 1980 and monthly thereafter, submit to the commissioner all detailed monitoring data required under the provisions of paragraph 6.

12) On or before July 31, 1980 and annually thereafter, submit for the review and approval of the Commissioner a detailed proposal for continuing biological studies, entrainment studies, and impingement monitoring as required by paragraph 5.

13) On or before April 30, 1981 and annually thereafter submit for the review and approval of the Commissioner a detailed report of the ongoing biological studies required by paragraph 5 and as approved under paragraph 12.

14) On or before July 31, 1981 submit for the review and approval of the Commissioner an engineering report studying the feasibility of modifying the cooling water intake screen wash system to improve the return of fish back to Long Island Sound.

15) On or before October 31, 1984 submit for the review and approval of the Commissioner an engineering report on continuous chlorination of the service water system for machroinvertebrate control for Unit 1 and Unit 2.

16) On or before October 31, 1985 submit for the review and approval of the Commissioner an engineering report on continuous chlorination and the minimization of the amount of chlorine necessary for macroinvertebrate control for Units 1, 2, and 3.

17) Upon initiation of the discharge of Unit 3 preoperational flush waters (primary and secondary sides) and hydrostatic testing condensor waters via Discharge Serial Nos. 006 and 007 and 001B-8, respectively, representative composite samples of the undiluted waste-streams shall be collected and analyzed in accordance with the pollutant parameters believed to be present in these waste-streams. This information should be used to recommend water quality monitoring for the period these discharges will occur. A report should be submitted for the review and approval of the Commissioner detailing any proposed monitoring and should include a compliance schedule for corrective actions if necessary.

The above described specific terms may be revised following public notice and public hearings, if requried, on the basis of a detailed engineering study if agreed by the Commissioner.

This order shall be considered as the permit required by Section 402 of the Federal Clean Water Act and shall expire on July 2, 1985.

This permit shall be modified, or alternatively, revoked and reissued, to comply with any applicable effluent standard or limitation issued or approved under Sections 301(b)(2), (C), and (D), 304(b)(2), and 307(a)(2) of the Clean Water Act, if the effluent standard or limitation so issued or approved:

1) Contains different conditions or is otherwise more stringent than any effluent limitations in the permit; or

2) Controls any pollutant not limited in the permit.

The permit as modified or reissued under this paragraph shall also contain any other requirements of the Act then applicable.

This order shall be subject to all the NPDES General Conditions dated April 27, 1979 which are hereby incorporated into this order.

Upon verification of full compliance with this order, a letter acknowledging this order to be equivalent of a permit issued under Section 22a-430, Subsection E; and/or a revised NPDES permit will be issued.

Entered as an Order Modification of the Commissioner on the <u>8th</u> day of <u>November</u>, 1983.

Stanley J. Pac
Commissioner

Order No. 2859 Modified
NPDES NO. CT0003263

c: Northeast Utilities Service Company
Attention: Mr. William C. Renfro

Original signed by Stanley J. Pac.

Unit Nos. 1, 2 and 3 Intakes (Before Condensers)

Specification:

Surveillance Requirements:

Parameter	Minimum Frequency of Sampling	Sample Type
Flow	Hourly	Instantaneous
Temperature (°F)	Hourly	Instantaneous
Settleable Solids	Weekly	Grab

Discharge Serial No. 001

Receiving Stream - Long Island Sound
Description - Discharge Points at Quarry Cut (East and West)
Average Daily Flow - 2,696,000,000 gallons
Maximum Temperature - 105°F

3A Specification:

1) The maximum temperature increase at the Quarry Cut above the intake water temperature shall be 32°F.

2) The differential temperature increase at the Quarry Cut above the intake water temperature under unusual conditions may be increased to 44°F for a period not exceeding 24 hours. In the event the temperature differential exceeds 32°F, the Department of Environmental Protection shall be immediately notified and a written report of the incident filed.

3) The permittee shall operate all facilities in such a manner as not to raise the average temperature of the receiving waters more than 4°F or increase the normal temperature of the receiving waters above 83°F. For purposes of this condition, cognizance will be given to reasonable time and distance to allow mixing of effluent and receiving waters, but the boundary of the mixing zone shall not exceed a radius of 8,000 feet from the discharge outlet at the quarry cut.

4) The thermal plume allowed within the permissible mixing zone as defined by these conditions shall not block zones of fish passage.

5) The discharge and operation of all facilities shall not alter significantly the color, turbidity, taste, odor or levels of coliform bacteria from ambient levels in the receiving waters; nor shall the level of dissolved oxygen in the receiving waters fall below 5.0 mg/l as a result of such discharge.

6) Discharge Serial Nos. 001, 001A, 001B and 001C shall:

   a) Have a pH between 6.0 and 9.0.

   b) Not contain as a result of additions from process operations any visible oil sheen, foam, sludge, deposits, grease, scum or cause silt or sand deposits other than of natural origin.

   c) Not contain more than 0.1 milliliters per liter settleable solids above the intake water concentration.

7) The residual chlorine concentration in the discharge at the Quarry Cut shall not exceed 0.1 mg/l.

8) The discharge shall contain no other chemical constituents in concentrations and combinations which are harmful to human, animal or aquatic life, or which make the waters unsafe or unsuitable for fish or shellfish or their propagation, impair the palatability of same, or impair the waters for other uses.

6A Surveillance Requirements:

Parameter	Minimum Frequency of Sampling	Sample Type
Flow	Hourly	Instantaneous
Temperature (°F)	Hourly	Instantaneous
pH	Hourly	Instantaneous
Settleable Solids	Weekly	Grab
Free Available Chlorine	Weekly	Grab
Total Residual Chlorine	Weekly	Grab

Report the following data:

1) Daily range of pH
2) Daily range of flow
3) Daily maximum temperature (°F)
4) Daily minimum temperature
5) Daily average temperature
6) Monthly standard deviation of temperature
7) Daily maximum temperature increase
8) Daily minimum temperature increase
9) Daily average temperature increase
10) Monthly standard deviation of temperature increase
11) Monthly maximum heat load (BTU/hr.)
12) Monthly minimum heat load
13) Monthly average heat load
14) Monthly maximum rate of change of heat load
15) Monthly standard deviation of heat load
16) Radioactive liquid releases

    a) Gross radioactivity (less tritium, gases and alpha)
        1) total release (curies)
        2) average concentration released (uCi/ml)
    b) Tritium
        1) total release (curies)
        2) average concentration released (uCi/ml)
    c) Dissolved gases
        1) total release (curies)
        2) average concentrations released (uCi/ml)
    d) Gross alpha
        1) total release (curies)
        2) average concentration released (uCi/ml)
    e) Volume of liquid waste discharged (liters)
    f) Volume of dilution water (liters)
    g) Isotopes released (curies)

h) Percent of 10 CFR 20, Appendix B, Table II for total release

i) Percent of technical specifications limit if different from 10 CFR 20, for the total release if such specifications are established by N.R.C.

Discharge Serial No. 001A
Description - Unit No. 1 Discharge
Average Daily Flow - 604,800,000 gallons per day
Maximum Temperature - 105°F
Average Design Temperature Increase - 22.5°F

3B Specification:

1) The maximum temperature increase at the Unit No. 1 discharge above the intake water temperature shall be 32°F.

2) The differential temperature increase at the Unit No. 1 discharge above the intake water temperature may be increased to 44°F for a period not exceeding 24 hours under conditions of reduced cooling water flow. In the event the temperature differential exceeds 32°F, the Department of Environmental Protection shall be notified in the monthly monitoring report.

3) The normal operating procedures include, usually not more than 12 times a year, the elevation of the intake water temperature on each condenser by a thermal backwash process required for the control of sea mussels. It is expected that the true temperature difference between the receiving stream and discharge water will exceed the permit limit for brief periods during this treatment schedule.

Parameter	Average Daily Quantity	Maximum Daily Quantity	Maximum Daily Concentration
Free Available Chlorine	229.21 kg/day	573.04 kg/day	0.25 mg/l

6B Surveillance Requirements:

Parameter	Minimum Frequency of Sampling	Sample Type
Flow	Hourly	Instantaneous
Temperature (°F)	Hourly	Instantaneous
pH	Hourly	Instantaneous
Settleable Solids	Weekly	Grab
Free Available Chlorine	Weekly	Grab

Report to the following data:

1) Daily range of pH
2) Daily range of flow
3) Daily maximum temperature (°F)
4) Daily minimum temperature
5) Daily average temperature
6) Monthly standard deviation of temperature
7) Daily maximum temperature increase
8) Daily minimum temperature increase
9) Daily average temperature increase
10) Monthly standard deviation of temperature increase

11) Monthly maximum heat load (BTU/hr.)
12) Monthly minimum heat load
13) Monthly average heat load
14) Monthly maximum rate of change of heat load
15) Monthly standard deviation of heat load
16) Radioactive liquid releases

    a) Gross radioactivity (less tritium, gases and alpha)
        1) total release (curies)
        2) average concentration released (uCi/ml)
    b) Tritium
        1) total release (curies)
        2) average concentration released (uCi/ml)
    c) Dissolved gases
        1) total release (curies)
        2) average concentration released (uCi/ml)
    d) Gross alpha
        1) total release (curies)
        2) average concentration released (uCi/ml)
    e) Volume of liquid waste discharged (liters)
    f) Volume of dilution water (liters)
    g) Isotopes released (curies)
    h) Percent of 10 CFR 20, Appendix B, Table I1 for total release
    i) Percent of technical specifications limit if different from 10 CFR 20, for the total release if such specifications are established by N.R.C.

Discharge Serial No. 001A-1
Description - Unit No. 1 Waste Sampling Tank Discharge
Average Flow per Batch - 25,000 gallons per batch
Expected Frequency of Discharge - Once per day
Temperature - Ambient

3C <u>Specification</u>:

6C <u>Surveillance Requirements</u>:

Parameter	Minimum Frequency of Sampling	Sample Type
Specific conductivity	Weekly	Grab
pH	Weekly	Grab

1) Record the total flow of batch discharge.

Discharge Serial No. 001A-2
Description - Unit No. 1 Floor Drain Sample Tank Discharge
Average Flow per Batch - 10,000 gallons per batch
Expected Frequency of Discharge - Once per day
Temperature - Ambient

3D Specification:

Parameter	Average Quantity Per Batch	Average Concentration Per Batch	Maximum Concentration Per Batch
Total Suspended Solids	1.14 kg/day	30.0 mg/l	45.0 mg/l

1) The maximum concentration specified above shall not be exceeded at any time.

6D Surveillance Requirements:

Parameter	Minimum Frequency of Sampling	Sample Type
Total Suspended Solids	Weekly	Grab
pH	Weekly	Grab

1) Record the total flow of batch discharge.

2) The monitoring report shall include a detailed explanation of any deviations from the limits specified in paragraph 2 and the corrective actions taken to achieve compliance.

Discharge Serial No. 001A-3
Description - Unit No. 1 Makeup Demineralizer Backwash Wastewater Discharge
Average Flow per Batch - 4,200 gallons per batch
Expected Frequency of Discharge - Once per day
Temperature - Ambient

3E <u>Specification</u>:

Parameter	Average Quantity Per Batch	Average Concentration Per Batch	Maximum Concentration Per Batch
Total Suspended Solids	0.48 kg/batch	30.0 mg/l	45.0 mg/l

1) The maximum concentration specified above shall not be exceeded at any time.

6E <u>Surveillance Requirements</u>:

Parameter	Minimum Frequency of Sampling	Sample Type
Total Suspended Solids	Weekly	Grab
pH	Weekly	Grab

1) Record the total flow of batch discharge.

2) The monitoring report shall include a detailed explanation of any deviations from the limits specified in paragraph 2 and the corrective actions taken to achieve compliance.

Discharge Serial No. 001A-4
Description - Unit No. 1 Decontamination Solution Tank Discharge
Average Flow per Batch - 3,500 gallons per batch
Expected Frequency of Discharge - Once per day
Temperature - Ambient

3F Specification:

Parameter	Maximum Quantity Per Batch
Boric Acid	7.6 kg

6F Surveillance Requirements

No sampling point available.

Discharge Serial No. 001A-5
Description - Unit No. 1 Auxiliary Heat Exchanger (Service Water) Discharge
Average Flow - 21,000 gallons per minute
Maximum Temperature - 85°F

3G Specification:

Parameter	Average Daily Quantity	Maximum Daily Quantity	Average Daily Concentration	Maximum Daily Concentration
Free Available Chlorine	*	28.65 kg/day	*	0.25 mg/l

*To be modified in accordance with the engineering reports as approved by the Commissioner required under Steps 15 and 16 of the subject permit/order.

6G Surveillance Requirements:

Parameter	Minimum Frequency of Sampling	Sample Type
Free Available Chlorine	Weekly	Grab
Total Suspended Solids	Weekly	Grab
pH	Weekly	Grab

1) Record the instantaneous flow at the time of grab sample collection.

2) The monitoring report shall include a detailed explanation of any deviations from the limits specified in paragraph 2 and the corrective actions taken to achieve compliance.

Discharge Serial No. 001A-5(a)
Description - Unit No. 1 Makeup Evaporator Discharge (Discharged to Discharge Serial No. 001A-5)
Average Flow - 30 gallons per minute
Maximum Temperature - 124°F

3H Specification:

6H Surveillance Requirements:

Parameter	Minimum Frequency of Sampling	Sample Type
Specific conductivity	Weekly	Grab

1) Record the instantaneous flow at the time of grab sample collection.

Discharge Serial No. 001B
Description - Unit No. 2 Discharge
Average Daily Flow - 778,000,000 gallons
Maximum Temperature - 105°F
Average Design Temperature Increase - 23°F

3I Specification:

1) The maximum temperature increase at the Unit No. 2 discharge above the intake water temperature shall be 32°F.

2) The differential temperature increase at the Unit No. 2 discharge above the intake water temperature may be increased to 44°F for a period not exceeding 24 hours under conditions of reduced cooling water flow. In the event the temperature increase exceeds 32°F, the Department of Environmental Protection shall be notified in the monthly monitoring report.

3) The normal operating procedures include, usually not more than 12 times a year, the elevation of the intake water temperature on each condenser by a thermal backwash process required for the control of sea mussels. It is expected that the true temperature difference between the receiving stream and discharge water will exceed the permit limit for brief periods during this treatment schedule.

Parameter	Average Daily Quantity	Maximum Daily Quantity	Maximum Daily Concentration
Free Available Chlorine	298.65 kg	737.15 kg	0.25 mg/l

6I Surveillance Requirments:

Parameter	Minimum Frequency of Sampling	Sample Type
Flow	Hourly	Instantaneous
Temperature	Hourly	Instantaneous
pH	Hourly	Instantaneous
Settleable Solids	Weekly	Grab
Free Available Chlorine	Weekly	Grab

Report the following data:

1) Daily range of pH
2) Daily range of flow
3) Daily maximum temperature (°F)
4) Daily minimum temperature
5) Daily average temperature
6) Monthly standard deviation of temperature
7) Daily maximum temperature increase

8) Daily minimum temperature increase
9) Daily average temperature increase
10) Monthly standard deviation of temperature increase
11) Monthly maximum heat load (BTU/hr.)
12) Monthly minimum heat load
13) Monthly average heat load
14) Monthly maximum rate of change of heat load
15) Monthly standard deviation of heat load
16) Radioactive liquid releases

    a) Gross radioactivity (less tritium, gases and alpha)
        1) total release (curies)
        2) average concentration released (uCi/ml)
    b) Tritium
        1) total release (curies)
        2) average concentration released (uCi/ml)
    c) Dissolved gases
        1) total release (curies)
        2) average concentrations released (uCi/ml)
    d) Gross alpha
        1) total release (curies)
        2) average concentration released (uCi/ml)
    e) Volume of liquid waste discharged (liters)
    f) Volume of dilution water (liters)
    g) Isotopes released (curies)
    h) Percent of 10 CFR 20, Appendix B, Table II for total release
    i) Percent of technical specifications limit if different from 10 CFR 20, for the total release if such specifications are established by N.R.C.

Discharge Serial No. 001B-1
Description - Unit No. 2 Blowdown Tank and Blowdown Quench
Tank Discharge
Average Daily Flow - 60,000 gallons per day
Temperature - Ambient

3J <u>Specification</u>:

Parameter	Average Daily Quantity	Maximum Daily Quantity	Average Daily Concentration	Maximum Daily Concentration
Total Suspended Solids	0.79 kg/day	1.59 kg/day	15.0 mg/l	30.0 mg/l

1) The maximum concentration specified above shall not be exceeded at any time.

6J <u>Surveillance Requirements</u>:

Parameter	Minimum Frequency of Sampling	Sample Type
Total Suspended Solids	Weekly	Grab

1) Record the instantaneous flow at the time of grab sample collection.

2) The monitoring report shall include a detailed explanation of any deviations from the limits specified in paragraph 2 and the corrective actions taken to achieve compliance.

Discharge Serial No. 001B-2
Description - Unit No. 2 Aerated Waste Monitor Tank Discharge
Average Batch Flow - 4,500 gallons per batch
Expected Frequency Discharge - Twice per day
Temperature - Ambient

3K Specification:

Parameter	Average Quantity Per Batch	Maximum Quantity Per Batch	Average Concentration Per Batch	Maximum Concentration Per Batch
Total Suspended Solids	0.51 kg/batch		30.0 mg/l	45.0 mg/l
Boric Acid	0.51 kg/batch	200.0 kg/batch		

1) A minimum of two (2) condenser circulating pumps shall be in service on Unit 2 during discharge.

2) The maximum concentration specified above shall not be exceeded at any time.

6K Surveillance Requirements:

Parameter	Minimum Frequency of Sampling	Sample Type
Boric Acid	Weekly	Grab
Total Suspended Solids	Weekly	Grab
pH	Weekly	Grab

1) Record the instantaneous flow at the time of grab sample collection.

2) The monitoring report shall include a detailed explanation of any deviations from the limits specified in paragraph 2 and the corrective actions taken to achieve compliance.

Discharge Serial No. 001B-3
Description - Unit No. 2 Coolant Waste Monitor Tank Discharge
Average Flow per Batch - 30,000 gallons per batch
Expected Frequency of Discharge - Once per day
Temperature - Ambient

3L Specification:

Parameter	Average Quantity Per Batch	Maximum Quantity Per Batch	Average Concentration Per Batch	Maximum Concentration Per Batch
Boric Acid	3.40 kg/batch	700.0 kg/batch		
Total Suspended Solids	1.70 kg/batch		15.0 mg/l	22.5 mg/l

1) If at any time the boric acid evaporator is not functional and the boric acid concentration exceeds 30 mg/l, a minimum of two (2) condenser circulating pumps shall be in service on Unit 2 during discharge.

2) The maximum concentration specified above shall not be exceeded at any time.

6L Surveillance Requirements:

Parameter	Minimum Frequency of Sampling	Sample Type
Boric Acid	Weekly	Grab
Total Suspended Solids	Weekly	Grab
pH	Weekly	Grab

1) Record the instantaneous flow at the time of grab sample collection.

2) The monitoring report shall include a detailed explanation of any deviations from the limits specified in paragraph 2 and the corrective actions taken to achieve compliance.

Discharge Serial No. 001B-4
Description - Unit No. 2 Makeup Demineralizer Backwash Wastewater Discharge
Average Flow per Batch - 9,500 gallons per batch
Expected Frequency of Discharge - Once per day
Temperature - Ambient

3M Specification:

Parameter	Average Quantity Per Batch	Average Concentration Per Batch	Maximum Concentration Per Batch
Total Suspended Solids	1.08 kg/batch	30.0 mg/l	45.0 mg/l

1) The maximum concentration specified above shall not be exceeded at any time.

6M Surveillance Requirements:

Parameter	Minimum Frequency of Sampling	Sample Type
Total Suspended Solids	Weekly	Grab
pH	Weekly	Grab

1) Record the instantaneous flow at the time of grab sample collection.

2) The monitoring report shall include a detailed explanation of any deviations from the limits specified in paragraph 2 and the corrective actions taken to achieve compliance.

Discharge Serial No. 001B-5
Description - Unit No. 2 Auxiliary Heat Exchanger (Service Water) Discharge
Average Flow - 10,000 gallons per minute
Maximum Temperature - 85°F

3N <u>Specification</u>:

Parameter	Average Daily Quantity	Maximum Daily Quantity	Average Daily Concentration	Maximum Daily Concentration
Free Available Chlorine	*	13.64 kg/day	*	0.25 mg/l

*To be modified in accordance with the engineering reports as approved by the Commissioner required under Steps 15 and 16 of the subject permit/order.

6N <u>Surveillance Requirements</u>:

Parameter	Minimum Frequency of Sampling	Sample Type
Free Available Chlorine	Weekly	Grab
Total Suspended Solids	Weekly	Grab
pH	Weekly	Grab

1) Record the instantaneous flow at the time of grab sample collection.

2) The monitoring report shall include a detailed explanation of any deviations from the limits specified in paragraph 2 and the corrective actions taken to achieve compliance.

Discharge Serial No. 001B-6
Description - Unit No. 2 Condensate Polisher Regeneration
Wastewater Neutralization Tank Discharge Including
System Floor Drains
Average Flow per Batch - 25,000 gallons per batch
Expected Frequency of Discharge - Twice per day
Temperature - Ambient

30 Specification:

Parameter	Average Quantity Per Batch	Average Concentration Per Batch	Maximum Concentration Per Batch
Total Suspended Solids	2.83 kg/batch	30.0 mg/l	45.0 mg/l
Oil and Grease	0.94 kg/batch	10.0 mg/l	20.0 mg/l

1) The maximum concentration specified above shall not be exceeded at any time.

60 Surveillance Requirements:

Parameter	Minimum Frequency of Sampling	Sample Type
Total Oil and Grease	Monthly	Grab
Total Suspended Solids	Weekly	Grab
pH	Weekly	Grab

1) Record the total flow of batch discharge.

2) The monitoring report shall include a detailed explanation of any deviations from the limits specified in paragraph 2 and the corrective actions taken to achieve compliance.

Discharge Serial No. 001B-7
Description - Unit No. 2 Condensate Polisher Auxiliary Heat Exchanger (Service Water) Discharge
Average Flow - 4,000 gpm
Maximum Temperature - 85°F

3P Specification:

Parameter	Average Daily Quantity	Maximum Daily Quantity	Maximum Daily Concentration
Free Available Chlorine	2.18 kg/day	5.46 kg/day	0.25 mg/l

1) This discharge will occur only when effluent from Discharge Serial No. 001B-6 is being evaporated instead of discharged.

6P Surveillance Requirements:

Parameter	Minimum Frequency of Sampling	Sample Type
Free Available Chlorine	Weekly	Grab
Total Suspended Solids	Weekly	Grab
pH	Weekly	Grab

1) Record the instantaneous flow at the time of grab sample collections.

Discharge Serial No. 001B-8
Description - Hydrostatic Testing Condenser Discharge (5/D)
Receiving Stream - Long Island Sound (Basin Code 2000)
Present/Future Water Quality Standard - SA/SA
Flow - 1,200,000 gallons per occurrence
Frequency of Discharge - Once

3Q Specification:

6Q Surveillance Requirements:

1) Perform analyses in accordance with paragraph 17.

Discharge Serial No. 001C
Description - Unit No. 3 Discharge
Average Daily Flow - 1,313,200,000 gallons
Maximum Temperature - 98°F
Average Design Temperature Increase - 18°F

3R Specification:

Parameter	Average Daily Quantity	Maximum Daily Quantity	Maximum Daily Concentration
Free Available Chlorine	553.7 kg/day	1386 kg/day	0.25 mg/l

1) The maximum temperature increase at the Unit No. 3 discharge above the intake water temperature shall be 24°F.

2) The differential temperature increase at the Unit No. 3 discharge above the intake water temperature under conditions of reduced cooling water flow may be increased to 30°F for a period of not exceeding 24 hours. In the event the temperature differential exceeds 24°F, the Department of Environmental Protection shall be notified in the monthly monitoring report.

3) The normal operating procedures include, usually not more than 12 times a year, the elevation of the intake water temperature on each condenser by a thermal backwash process required for the control of sea mussels. It is expected that the true temperature difference between the receiving stream and discharge water will exceed the permit limit for brief periods during this treatment schedule.

4) Chlorine will be used to control biofouling in the event of malfunction or inadequate performance of the mechanical condenser cleaning system. It may also be required to prevent biofouling of the ball collection device.

6R Surveillance Requirements:

Parameter	Minimum Frequency of Sampling	Sample Type
Flow	Hourly	Instantaneous
Temperature (°F)	Hourly	Instantaneous
pH	Hourly	Instantaneous
Settleable Solids	Weekly	Grab
Free Available Chlorine	Weekly	Grab

Report the following data:

1) Daily range of pH
2) Daily range of flow
3) Daily maximum temperature (°F)
4) Daily minimum temperature
5) Daily average temperature
6) Monthly standard deviation of temperature
7) Daily maximum temperature increase
8) Daily minimum temperature increase
9) Daily average temperature increase
10) Monthly standard deviation of temperature increase
11) Monthly maximum heat load (BTU/hr.)
12) Monthly minimum heat load
13) Monthly average heat load
14) Monthly maximum rate of change of heat load
15) Monthly standard deviation of heat load
16) Radioactive liquid releases

    a) Gross radioactivity (less tritium, gases and alpha)
        1) total release (curies)
        2) average concentration released (uCi/ml)
    b) Tritium
        1) total release (curies)
        2) average concentration released (uCi/ml)
    c) Dissolved gases
        1) total release (curies)
        2) average concentration released (uCi/ml)
    d) Gross alpha
        1) total release (curies)
        2) average concentration released (uCi/ml)
    e) Volume of liquid waste discharged (liters)
    f) Volume of dilution water (liters)
    g) Isotopes released (curies)
    h) Percent of 10 CFR 20, Appendix B, Table Il for total release
    i) Percent of technical specifications limit if different from 10 CFR 20, for the total release if such specifications are established by N.R.C.

Discharge Serial No. 001C-1
Description - Unit No. 3 Steam Generator Blowdown Discharge
Average Daily Flow - 288,000 gallons
Maximum Temperature - 200°F

3S Specification:

Parameter	Average Daily Quantity	Average Daily Concentration	Maximum Concentration
Total Suspended Solids	32.7 kg/day	30.0 mg/l	60.0 mg/l

1) The maximum concentration specified above shall not be exceeded at any time.

6S Surveillance Requirements:

Parameter	Minimum Frequency of Sampling	Sample Type
Boric Acid	Weekly	Grab
Total Suspended Solids	Weekly	Grab
pH	Weekly	Grab

1) Record the instantaneous flow at the time of grab sample collection.

2) The monitoring report shall include a detailed explanation of any deviations from the limits specified in paragraph 2 and the corrective actions taken to achieve compliance.

Discharge Serial No. 001C-2
Description - Unit No. 3 Waste Test Tank Discharge
Average Flow per Batch - 21,000 gallons per batch
Expected Frequency of Discharge - Twice per day
Temperature - Ambient

3T **Specification:**

Parameter	Maximum Quantity Per Batch
Boric Acid	800 kg

1) A minimum of two (2) condenser circulating pumps shall be in service on Unit 3 during discharge.

6T **Surveillance Requirements:**

Parameter	Minimum Frequency of Sampling	Sample Type
Boric Acid	Weekly	Grab
Lithium	Weekly	Grab
Specific conductivity	Weekly	Grab
pH	Weekly	Grab

1) Record the instantaneous flow at the time of grab sample collection.

Discharge Serial No. 001C-3
Description - Low Level Waste Drain Tank Discharge
Average Flow per Batch - 4,000 gallons
Expected Frequency of Discharge - Four times per day
Temperature - Ambient

3U Specification:

Parameter	Average Quantity Per Batch	Maximum Quantity Per Batch	Average Concentration Per Batch	Maximum Concentration Per Batch
Boric Acid	0.45 kg/batch	200.0 kg/batch		
Total Suspended Solids	0.45 kg/batch		30.0 mg/l	45.0 mg/l

1) If at any time the boric acid evaporator units are not functional and the boric acid concentration exceeds 30 mg/l, a minimum of two (2) condenser circulating pumps shall be in service on Unit 3.

6U Surveillance Requirements:

Parameter	Minimum Frequency of Sampling	Sample Type
Boric Acid	Weekly	Grab
Total Suspended Solids	Weekly	Grab
pH	Weekly	Grab

1) Record the total flow of batch discharge.

2) The monitoring report shall include a detailed explanation of any deviations from the limits specified in paragraph 2 and the corrective actions taken to achieve compliance.

Discharge Serial No. 001C-[illegible]
Description - Unit No. 3 Makeup Demineralizer Backwash Wastewater Discharge
Average Flow per Batch - 80,000 gallons
Expected Frequency of Discharge - Once per day
Temperature - Ambient

5V Specification:

Parameter	Average Quantity Per Batch	Average Concentration Per Batch	Maximum Concentration Per Batch
Total Suspended Solids	9.08 kg/batch	30.0 mg/l	45.0 mg/l

1) The maximum concentrations specified above shall not be exceeded at any time.

6V Surveillance Requirements:

Parameter	Minimum Frequency of Sampling	Sample Type
Total Suspended Solids	Weekly	Grab
pH	Weekly	Grab

1) Record the total flow of batch discharge.

2) The monitoring report shall include a detailed explanation of any deviations from the limits specified in paragraph 2 and the corrective actions taken to achieve compliance.

Discharge Serial No. 001C-5
Description - Unit No. 3 Auxiliary Heat Exchanger (Service Water)
Discharge
Average Flow - 30,000 gallons per minute
Maximum Temperature - 90°F

3W Specification:

Parameter	Average Daily Quantity	Maximum Daily Quantity	Average Daily Concentration	Maximum Daily Concentration
Free Available Chlorine	*	40.93 kg/day	*	0.25 mg/l

*To be modified in accordance with the engineering reports as approved by the Commissioner required under Steps 15 and 16 of the subject permit/order.

6W Surveillance Requirements:

Parameter	Minimum Frequency of Sampling	Sample Type
Free Available Chlorine	Weekly	Grab
Total Suspended Solids	Weekly	Grab
pH	Weekly	Grab

1) Record the instantaneous flow at the time of grab sample collection.

Discharge Serial No. 002
Description - Unit No. 1 Screen Washwater Discharge
Receiving Stream - Niantic Bay
Average Daily Flow - 252,000 gallons
Maximum Daily Flow - 2,016,000 gallons
Temperature - Ambient

3X <u>Specification</u>:

6X <u>Surveillance Requirements</u>:

Discharge Serial No. 003
Description - Unit No. 2 Screen Washwater Discharge
Receiving Stream - Niantic Bay
Average Daily Flow - 317,000 gallons
Maximum Daily Flow - 2,540,000 gallons
Temperature - Ambient

3Y **Specification**:

6Y **Surveillance Requirements**:

Discharge Serial No. 004
Description - Unit No. 3 Screen Washwater Discharge
Receiving Stream - Niantic Bay
Average Daily Flow - 720,000 gallons
Maximum Daily Flow - 5,760,000 gallons
Temperature - Ambient

3Z <u>Specification</u>:

6Z <u>Surveillance Requirements</u>:

Discharge Serial No. 005
Description - Unit No. 1 Non-contaminated Floor Drain,
Transformer Yard Drains and Surface Water Runoff
Receiving Stream - Long Island Sound via Quarry Cut
Flow - Variable
Temperature - Ambient

3AA Specification:

Parameter	Average Daily Concentration	Maximum Concentration
Oil and Grease	10.0 mg/l	20.0 mg/l

1) The maximum concentration specified above shall not be exceeded at any time.

6AA Surveillance Requirements:

Parameter	Minimum Frequency of Sampling	Sample Type
Oil and Grease	See Note 1	Grab

1) Monitor monthly for oil and grease when oil separator discharge occurs.

2) Record the instantaneous flow at the time of grab sample collection.

3) The monitoring report shall include a detailed explanation of any deviations from the limits specified in paragraph 2 and the corrective actions taken to achieve compliance.

Discharge Serial No. 006
Description - Unit No. 2 and 3 Non-contaminated Floor Drain, Unit 3 Construction Water Discharge, Surface Water Runoff and Unit 3 Preoperational Flush Discharge (Primary Side)
Receiving Stream - Niantic Bay
Flow - Variable
Temperature - Ambient

3BB Specification:

Parameter	Average Daily Concentration	Maximum Concentration
Oil and Grease	10.0 mg/l	20.0 mg/l

1) The maximum concentration specified above shall not be exceeded at any time.

6BB Surveillance Requirements:

Parameter	Minimum Frequency of Sampling	Sample Type
Oil and Grease	See Note 1	Grab

1) Monitor monthly for oil and grease when oil separator discharge occurs.

2) Record the instantaneous flow at the time of grab sample collection.

3) The monitoring report shall include a detailed explanation of any deviations from the limits specified in paragraph 2 and the corrective actions taken to achieve compliance.

Discharge Serial No. 007
Description - Unit No. 3 Non-contaminated Floor Drain Discharge,
Preoperational Flush Discharge (Primary and Secondary
Sides) and Surface Water Runoff
Receiving Stream - Niantic Bay via Settling Pond
Flow - Variable
Temperature - Ambient

3CC Specification:

Parameter	Average Daily Concentration	Maximum Concentratic
Oil and Grease	10.0 mg/l	20.0 mg/l

1) The maximum concentration specified above shall not be exceeded at any time.

6CC Surveillance Requirement:

Parameter	Minimum Frequency of Sampling	Sample Type
Oil and Grease	Monthly	Grab

1) Record the instantaneous flow at the time of grab sample collection.

2) The monitoring report shall include a detailed explanation of any deviations from the limits specified in paragraph 2 and the corrective actions taken to achieve compliance.

Discharge Serial No. 008
Description - Unit No. 1 Non-contaminated Floor Drains and Surface Water Runoff
Receiving Stream - Niantic Bay
Flow - Variable
Temperature - Ambient

3DD **Specification**:

Parameter	Average Daily Concentration	Maximum Concentration
Oil and Grease	10.0 mg/l	20.0 mg/l

1) The maximum concentration specified above shall not be exceeded at any time.

6CC **Surveillance Requirements**:

Parameter	Minimum Frequency of Sampling	Sample Type
Oil and Grease	See Note 1	Grab

1) Monitor monthly for oil and grease when oil separator discharge occurs.

2) Record the instantaneous flow at the time of grab sample collection.

3) The monitoring report shall include a detailed explanation of any deviations from the limits specified in paragraph 2 and the corrective actions taken to achieve compliance.

Discharge Serial No. 009
Description - Unit No. 2 Non-contaminated Floor Drains,
Fire Pump House Floor Drains, and Surface Water Runoff
Receiving Stream - Long Island Sound via Quarry Cut
Flow - Variable
Temperature - Ambient

3EE Specification:

Parameter	Average Daily Concentration	Maximum Concentration
Oil and Grease	10.0 mg/l	20.0 mg/l

1) The maximum concentration specified above shall not be exceeded at any time.

6EE Surveillance Requirements:

Parameter	Minimum Frequency of Sampling	Sample Type
Oil and Grease	See Note 1	Grab

1) Monitor monthly for oil and grease when oil separator discharge occurs.

2) Record the instantaneous flow at the time of grab sample collection.

3) The monitoring report shall include a detailed explanation of any deviations from the limits specified in paragraph 2 and the corrective actions taken to achieve compliance.

SECTION 22a-430

GENERAL CONDITIONS

These general conditions apply to all permits issued by the Department of Environmental Protection which are for groundwater discharges and sanitary sewer connections.

1. Any person or municipality wishing to initiate, create or originate any new discharge of water, substances or material into the groundwaters or a sanitary sewer which discharges to the waters of the State of Connecticut shall file an application for a permit no later than 180 days in advance of the date on which it is desired to commence the discharge.

2. Any application filed in accordance with condition (1) shall be signed as follows:

   (a) In the case of corporations, by a principal executive officer of at least the level of vice-president or his duly authorized representative, if such representative is responsible for the overall operation of the facility from which the discharge originates.

   (b) In the case of a partnership, by a general partner.

   (c) In the case of sole proprietorship, by the proprietor.

   (d) In the case of a municipal, state, or other public facility, by either a principal executive officer, ranking elected official or other duly authorized employee.

3. All discharges authorized by any permit shall be consistent with the terms and conditions of the permit.

4. Facility expansion, production increases or process modification which may result in new or increased discharges of water, substances or material to the waters of the State of Connecticut must be authorized by the issuance of a new or revised permit prior to being initiated, created or originated unless such discharges do not violate the terms and conditions of an existing permit.

5. The discharge of water, substances or material more frequently than, or at a level in excess of the terms and conditions of any existing permit shall constitute a violation of the terms and conditions of the permit under Section 25-54i of the Connecticut General Statutes as amended which are not subject to NPDES permits issued under Section 402 of the Federal Water Pollution Control Act. Specifically, these General Conditions apply to discharges to municipal sanitary sewer systems, and to the groundwaters of the State.

6. Any permit may be modified, revoked, or suspended in accordance with applicable state statutes, regulations and other administrative

procedures in whole or part during its term for cause including but not limited to the following:

(a) Violation of any term or condition of the permit:

(b) Obtaining a permit by misrepresentation or failure to disclose fully all relevant facts; and

(c) A change in any condition that requires either a temporary or permanent reduction or elimination of the discharge.

7. The Commissioner or his authorized representatives, or presentation of credentials shall be permitted:

(a) To enter upon the premises in which the effluent source is located or in which any records are required to be kept under the terms and conditions of the permit;

(b) To have access to and copy any records required to be kept under the terms and conditions of the permit;

(c) To inspect any monitoring equipment or method required in the permit; or

(d) To sample any discharge of water, substances or material to the waters of the State of Connecticut.

8. The recipient of any permit shall at all times maintain in good working order, and operate as efficiently as possible, any Facility or system of control installed to achieve compliance with the terms and conditions in the permit.

9. Any recipient of a permit who wishes to continue to discharge water, substance or material to the waters of the State of Connecticut after the expiration date of the permit shall file for a reissuance of the permit on a form prescribed by the Commissioner no less than 180 days in advance of the date of expiration.

10. The recipient of any permit shall:

(a) Maintain records of all information resulting from any monitoring program contained in the terms and conditions of the permit;

(b) Identify in the monitoring records 1) the date, the exact place and the time of sampling; 2) the dates analyses were performed; 3) who performed the analyses; 4) the analysis techniques and methods used; 5) the results of such analysis;

(c) Retain for a minimum of three years, or longer if specifically required by the Commissioner, any records of monitoring activities and results including all original strip chart readings from continuous monitoring instrumentation and calibration and maintenance records;

(d) Report on forms prescribed by the Commissioner the monitoring results obtained in accordance with specified terms and conditions of any permit.

11. For the purpose of complying with the monitoring requirements prescribed in the terms and conditions of any permit, the sampling, preservation, handling and analytical methods used must conform to the following referenced methods latest edition. However, different but equivalent methods are allowed if they receive prior written approval of the Commissioner.

(a) Standard Methods for the Examination of Water and Wastewaters, 13th Edition, 1971, American Public Health Association, New York, New York 10019.

(b) A.S.T.M. Standards, Part 23, Water; Atmospheric Analysis, 1970; American Society of Testing and Materials, Philadelphia, Pennsylvania 10029.

(c) Methods for Chemical Analysis of Water and Wastewaters, April 1971, Environmental Protection Agency, Water Quality Office, Analytical Water Quality Control Laboratory, 1014 Broadway, Cincinnati, Ohio 45268.

12. Abbreviations and Definitions

mg/l - milligrams per liter

lbs/day - pounds per day

kg/day - kilograms per day

Composite Sample - 1) Industrial wastewaters - A mixture of aliquot samples obtained at regular intervals over a time period. The volume of each individual aliquot shall be proportional to the discharge flow rate or the sampling interval (for constant volume samples) shall be proportional to the flow rate over the time period used to obtain the composite. A composite sample shall contain at least four aliquot samples collected over a four-hour period.
2) Municipal and sanitary wastewater - A sample consisting of a minimum of eight grab samples collected at equal intervals of no less than 30 minutes during a 24-hour period and combined proportional to flow, or a sample continuously collected proportionally to flow over that same time period.

Grab Sample - An individual sample collected in less than 15 minutes.

Range During Composite - The maximum and minimum values of a parameter observed in the aliquot samples used to make a composite sample.

Four-Hour Average - The average of a minimum of four measurements obtained at regular intervals during composite sample collection.

Average - The arithmetic average.

Daily Average - The average of a minimum of eight measurement obtained at regular intervals over an operating day.

Average Daily Concentration - The average concentration during a 24-hour period of an operating day. The minimum procedure for determining the average daily concentration will be a four-hour composite.

Maximum Concentration - Maximum concentration at any time as determined by a grab sample.

Average Daily Flow - The average flow rate during an operating day.

Average Daily Quantity - The average quantity of waste generated during an operating day.

Monthly Average - The average of a minimum of twelve composite samples taken on twelve separate days, or at least one grab sample per day, taken on twelve separate days, as required for the parameter being reported within a calendar month.

Weekly Average - The average of a minimum of three composite samples taken on three separate days, or at least one grab sample per day, taken on three separate days, as required for the parameter being reported within a week.

Maximum Daily Quantity - The maximum quantity of waste generated during a 24-hour period.

Cooling Water - Water used for cooling purpose only, which contains heat, but which has no direct contact with any product or raw material.

Metal Concentration - All metal concentrations are expressed as total metal concentrations.

Cyanide - Cyanide which is amendable to destruction by chlorine.

APPROVED ______________________________ DATE April 27, 1979
Stanley J. Pac
COMMISSIONER
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Original signed by Stanley J. Pac.

APPENDIX H

HISTORIC AND ARCHEOLOGIC SITES

APPENDIX H

HISTORIC AND ARCHEOLOGIC SITES

This appendix contains a list of sites currently listed or eligible for inclusion in the National Register of Historic Places within 16 km of Millstone 3 and a letter from John W. Shannahan, State Historic Preservation Officer, to H. C. Liang, Stone & Webster Engineering Corporation, dated January 5, 1981.

SITES LISTED OR ELIGIBLE FOR LISTING IN THE NATIONAL REGISTER OF HISTORIC PLACES WITHIN 16 KM OF MILLSTONE 3

AREA	Property
East Lyme	Thomas Avery House
	Thomas Lee House
	Niantic River Railroad Bridge
	Niantic River Highway Bridge
	Rocky Neck Pavilion
	Samuel Smith House
Groton	Building 70
	Fort Griswold
	Groton Bank Historic District
	Groton Railroad Bridge
	Haley House
	Jabez Smith House
	Edward Yeoman House
	U.S.S. Nautilus (submarine)
New London	Acors Barns House
	Bank Street Historic District
	Bulkeley School
	Deshon-Allyn House
	Downtown New London Historic District
	Fort Trumbull
	Franklin Street Historic District
	Jonathan Newton Harris House
	Joshua Hempstead House
	Nathaniel Hempstead House
	Huntington Street Baptist Church
	138-148 Huntington Street
	Ledge Lighthouse
	Monte Cristo Cottage
	New London County Courthouse
	New London Custom House
	New London Public Library
	New London Railroad Station
	Old Town Mill
	Shaw's Cove Bridge
	Shaw Mansion
	Starr Street Area
	St. James Episcopal Church
	Thames Shipyard
	Whale Oil Row
	Williams Memorial Institute
	Winthrop Mill
	Nathan A. Woodworth House

AREA	Property
Old Lyme	Old Lyme Historic District Peck Tavern

Source: U.S. Department of the Interior, National Park Service, National Registers, 1979, 1980, 1981, 1982, 1983, 1984.

Office of the
STATE
HISTORIC
PRESERVATION
OFFICER
for Connecticut

59 SOUTH PROSPECT STREET · HARTFORD, CONNECTICUT 06106 · TEL (203) 566-3005

January 5, 1981

Mr. H. C. Liang
Lead Environmental Engineer
Stone & Webster Engineering
Corporation
P.O. Box 2325
Boston, MA 02107

NOTED JAN 11 1982 H.C.LIANG

Subject: Data Request - Erols Section 2.6
Millstone Nuclear Power Station - Unit 3
Northeast Utilities Service Company

Dear Mr. Liang:

With respect to your request for information as to the architectural, historical and archaeological resources located within 10 km of Millstone - Unit 3, the following data are provided.

The following properties are listed on the National Register of Historic Places:

East Lyme	Thomas Lee House	CT 156 & Giant's Neck Road
	Thomas Avery House	Society Road
	Samuel Smith House	82 Plants Dam Road
New London	Barns, Acors, House	68 Federal Street
	Deshon-Allyn House	613 William Street
	Fort Trumbull	Fort Neck (HAER)
	Hempstead, Joshua, Hse.	11 Hempstead Street
	Hempstead, Nathaniel, House	Corner of Jay, Hempstead, Coit, and Truman Streets
	Monte Cristo Cottage	325 Pequot Avenue
	New London County Courthouse	70 Hunting Street
	New London Custom Hse.	150 Bank Street
	New London Public Library	63 Huntington Street
	New London Railroad Station	State Street
	Shaw Mansion	11 Blinman Street
	Thames Shipyard	Farnsworth Street
	Whale Oil Row	105-119 Huntington Street
	William Memorial Inst.	110 Broad Street

STATE HISTORIC PRESERVATION OFFICER: The person responsible for implementation in Connecticut of the National Historic Preservation Act of 1966 administered by the Department of the Interior, Heritage Conservation and Recreation Service, Washington, D.C.

AN EQUAL OPPORTUNITY EMPLOYER/AFFIRMATIVE ACTION AGENCY

The following properties have been declared eligible for the National Register of Historic Places by the Secretary of the Interior:

East Lyme	Niantic River Railroad Bridge	Crosses Niantic River (HAER)
	Niantic River Highway Bridge	Crosses Niantic River (HAER)
Groton	Groton Bridge	Over Thames River (HAER)
New London	Old Town Mill	Mill & State Pier Sts.
	Shaw's Cove Bridge	Over Shaw's Cove (HAER)
	Starr Street Area	-
	Bank Street Historic District	-
	Ledge Lighthouse	New London harbor
	Franklin Street Historic District	-
	138-48 Huntington Street	-
	St. James Episcopal Church	125 Huntington Street

Please find enclosed the appropriate pages from Historic Preservation A Plan for Connecticut. Vol.II: An Inventory (Connecticut Historical Commission, 1974), which identifies architectural and historical resources within the area. In addition, properties identified by The Historic American Engineering Record has possessing engineering or industrial significance have been annotated with "HAER".

Further, please find enclosed the relevant zerox sections of a "scan" survey which this agency undertook in order to preliminarily identify potentially significant clusters of architectural resources. Minimal descriptive documentation exists to supplement this graphic data.

In general, as no systematic survey of Connecticut's archaeological resources has been accomplished to date, little information exists as to actual archaeological site density and distribution. However, coastal areas and major river drainage systems, such as, the Niantic River - Niantic Bay confluence, are especially sensitive with respect to the existence of prehistoric archaeological resources. In particular, the enclosed survey data should be of assistance; The State Historic Preservation Officer requests that the specific locational data for archaeological resources be treated in a confidential manner in accordance with Connecticut Public Act 81-286 in order to ensure continued preservation of these resources.

It should be realized that the above provided information represents an incomplete inventory of the architectural, historical and archaeological resources within the defined area.

In the opinion of the State Historic Preservation Officer the granting of an operating permit for Millstone Nuclear Power Station Unit 3 will have no impact upon historical, architectural and archaeological resources either listed on or eligible for the National Register of Historic Places.

For further information, please contact David A. Poirier, Archaeologist.

Sincerely,

John W. Shannahan
State Historic Preservation
Officer

DAP/ij

cc: Raul de Brigard
Northeast Utilities

APPENDIX I
FISHERY ESTIMATES IN THE VICINITY OF MILLSTONE UNIT 3

APPENDIX I

FISHERY ESTIMATES IN THE VICINITY OF MILLSTONE UNIT 3

Millstone 3 is located in the Town of Waterford, Connecticut, on the north shore of Long Island Sound and at the east shore of Niantic Bay. An 80-km (50-mile) radius of the plant encompasses over 50% of Long Island Sound, extends into the Atlantic Ocean about 40 km (25 miles), and includes most of Rhode Island. These areas not only support excellent commercial fisheries of fish and shellfish, but provide a substantial recreational harvest as well.

1 METHODS

1.1 Commercial Harvests

Commercial landings by state and waterbody of capture served as a basis for estimating commercial harvest. Only those fish used for human consumption were included in the analysis. Each of the three states affected by the 80-km radius was treated slightly differently, depending on their method of reporting.

1.1.1 Connecticut

Connecticut records finfish and lobster landings by geographical area (Figure 1). These areas include Long Island Sound, Block Island Sound, and offshore. These areas were grouped into three units because of their geographical and hydrological characteristics. Unit I includes areas 1, 2, 5, 6, and 7, which are those areas most likely to be immediately affected by potential releases from Millstone. Unit II includes areas 3 and 4. Only about 10% of these two areas is within the 80-km radius; thus, a range of 10% to 100% of the catch in Unit II is used in the analysis. Unit III is composed of area 8. All of the catch in this unit is used in the analysis, although some of the catch is probably outside the radius. That portion outside the radius cannot be defined because the seaward boundary of the area is not defined.

National Marine Fisheries Service (NMFS) data were used for other shellfish. These data include the portions of Long Island Sound not potentially affected by Millstone 3; thus, they may be slight overestimates of the potentially affected harvest.

1.1.2 Rhode Island and New York

Rhode Island and New York landings were obtained from the NMFS. These landings are broken down into two geographical units. Unit I is Long Island Sound, and Unit II is the area in Block Island Sound as well as that part of the Atlantic Ocean within the 80-km radius.

1.2 Recreational Harvest

The recreational finfish harvest was estimated using data obtained by the NMFS in 1979 for the East and Gulf Coastal states. For the North Atlantic region--which includes Maine, New Hampshire, Rhode Island, and Connecticut--the mean weight per fish caught was 0.74 kg. Numbers of fish caught by recreational fishermen were recorded by state. For Connecticut and Rhode Island, all fish caught recreationally were judged to be within the 80-km radius of Millstone 3; for New York, 50% of the recreational fishing was judged to be within the 80-km radius.

Recreational harvest estimates of shellfish are difficult to make because of lack of information. However, Connecticut determined that during a 6-year sampling period (1976-1981), the recreational harvest of the American lobster was equal to about 10% (range of 8.5 to 12.6%) of the commercial harvest.* The 10% figure is used for all states.

Recreational clamming and scalloping data exist only as numbers of permits issued by some local seafood commissions. The East Lyme-Waterford Seafood Commission controls some of the most productive waters in the State of Connecticut. This area is in the Niantic River estuary and covers approximately 330 hectares (815 acres). The commission issued about 8000 licenses in 1982 for collection of scallops, clams, and oysters. The majority of the licenses were for 1-day permits to collect 1 bushel of scallops or clams (according to telephone conversations with Gregory Marin of the East Lyme-Waterford Shellfish Commission, on October 19 and 21, 1983).

For this analysis it was assumed that (1) the total harvest was clams (which yields two times more meat per bushel than scallops) and the daily limit of 1 bushel was collected; (2) the seasonal licenses that allow clams to be taken daily increased the total harvest that could be obtained only with 1-day licenses by 25%; and (3) this harvest represents 50% of the harvest in the state. The last assumption is based on the lack of "clean" waters elsewhere in the state.

The recreational harvest was then divided by the Connecticut commercial harvest, which was reported only for private hard clams, and that proportion was used to calculate the Rhode Island recreational harvest. In Rhode Island, only public hard clam harvests were reported in the commercial hard clam statistics. The proportion developed for Connecticut was multiplied by the Rhode Island harvest (1980-1982) to arrive at an estimated recreational harvest for Rhode Island. No hard clams were reported harvested for New York in the 80-km radius around Millstone.

2 RESULTS

2.1 Connecticut

2.1.1 Commercial Harvest

Estimates of commercial finfish harvests for Connecticut by unit are given in Table 1. Areas used for the unit determinations are shown in Figure 1. Shellfish harvests are shown in Table 2.

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*State of Connecticut, Marine Fisheries Information System, Department of Environmental Protection, Bureau of Fisheries, "Marine Fisheries," 1983.

Table 1 indicates that the mean harvest for edible finfish and squid in the three units is 5.08×10^5 kg (1.12×10^6 lb). Assuming that only 10% of Unit II is potentially affected by Millstone reduces this number to 4.81×10^5 kg (1.07×10^6 lb). Shellfish harvests total 1.16×10^6 kg (2.56×10^6 lb) for Connecticut.

2.1.2 Recreational Harvest

Recreational harvests of finfish in Connecticut are estimated to be 7.8×10^6 fish which weighed 5.8×10^6 kg (1.3×10^7 lb). A recreational lobster harvest equal to 10% of the commercial harvest (Table 2) would be 4.44×10^4 kg (9.78×10^4 lb).

Geographical Unit II accounts for 36% of this harvest (Connecticut, 1983). If only 10% of the harvest within geographical Unit II is assumed to be potentially affected by Millstone 3, the harvest would decrease by 32.4% or would be equal to 3.00×10^4 kg (6.61×10^4 lb). Thus, the recreational harvest for lobster is estimated to range between 3.00×10^4 kg and 4.4×10^4 kg (6.61×10^4 lb and 9.8×10^4 lb).

Clam harvests are assumed to be twice the estimated Niantic River harvest of 10,000 bushels. Thus, the state harvest is considered to be 20,000 bushels, and a 12.0 conversion factor is used to convert a bushel of clams to a pound of meat. Therefore, the harvest is estimated to be 1.09×10^5 kg (2.40×10^5 lb). This estimated harvest is 65% of the average commercial harvest in Connecticut during 1980-1982, which was 1.67×10^5 kg (3.68×10^5 lb).

2.2 Rhode Island and New York

2.2.1 Commercial Harvest

Commercial finfish harvests for Rhode Island and New York are given in Table 3. The yearly mean weight of the harvest for both the Atlantic Ocean and Long Island Sound during the 1980-1982 period was 1.21×10^7 kg (2.66×10^7 lb).

2.2.2 Recreational Harvest

During the recreational finfish survey done by the NMFS, Rhode Island fishermen caught 6610 fish and New York fishermen caught 33,644 fish that weighed an average of 0.74 kg. Assuming the Rhode Island catch and 50% of the New York catch were within the 80-km radius, the recreational catch equaled 1.73×10^4 kg (3.82×10^4 lb).

Recreational catches of invertebrates were as follows:

(1) Lobster--0.1 (2.65×10^5 kg [5.84×10^5 lb]) = 2.65×10^4 kg (5.84×10^4 lb)

(2) Clams--0.65 (1.61×10^6 kg [3.55×10^6 lb]) = 1.04×10^6 kg (2.30×10^6 lb)

3 CONCLUSIONS

Commercial landings of finfish within the 80-km (50-mile) radius of Millstone are calculated to consist of 1.26×10^{7} kg (2.78×10^{7} lb) yearly. Shellfish harvests equal an additional 6.27×10^{6} kg (1.38×10^{7} lb) for a total production of 1.89×10^{7} kg (4.16×10^{7} lb). Assuming only 10% of the upper portion of Long Island Sound is potentially unaffected by Millstone does not appreciably reduce this total production value.

Recreational harvests of finfish total 5.82×10^{6} kg yearly. Shellfish harvests equal an additional 1.28×10^{6} kg (2.83×10^{6} lb). Assuming only 10% of the upper portion of Long Island Sound is affected reduces this number to 1.27 x 106 kg (2.80×10^{6} lb). Thus, total recreational harvest is between 7.09×10^{6} and 7.10×10^{6} kg (1.56×10^{7} and 1.57 lb).

The total commercial and recreational catch of fish and shellfish within the 80-km (50-mile) radius of Millstone 3 is estimated to be 2.60×10^{7} kg (5.73×10^{7} lb).

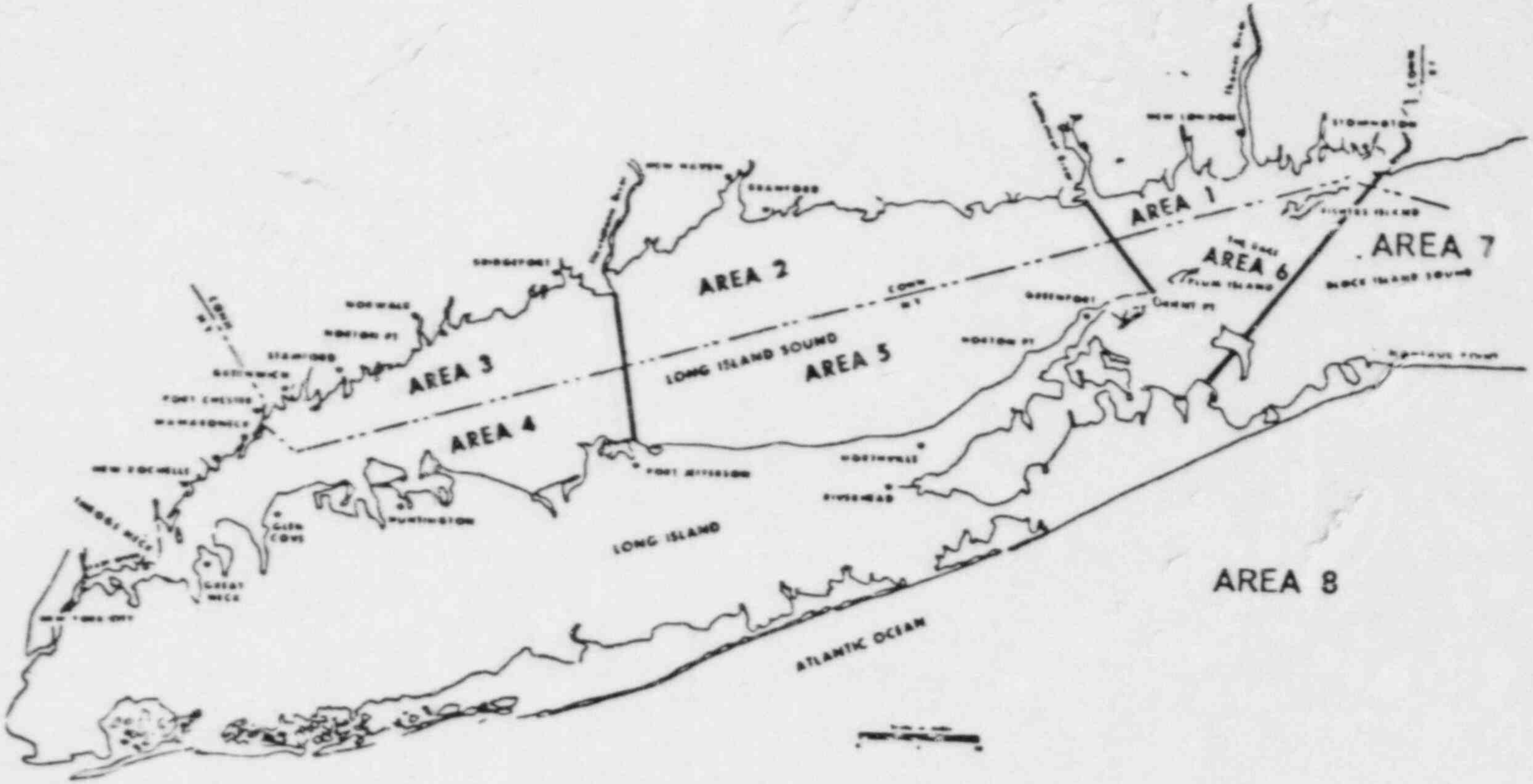

Figure 1 Long Island Sound fishing areas

Table 1. Connecticut commercial catch (lbs) of foodfish and squid in three geographical units within an 80 kilometer radius of Millstone III.[a]

Species	Unit I[b]				Unit II[b]				Unit III[b]				Total			Mean
	1980	1981	1982	x	1980	1981	1982	x	1980	1981	1982	x	1980	1981	1982	
1. Flounder (blackback)	472,634	531,732	386,927	463,764	4,680	2,082	13,837	6,866	14,378	32,767	24,797	23,981	491,692	566,581	425,561	494,611
2. Fluke	42,905	52,790	14,211	36,635	796	1,642	287	908	5,039	28,883	0	11,307	48,740	85,315	14,498	48,851
3. Mackeral	1,918	113	643	891	165	0	431	199	0	0	0	0	2,083	113	1,074	1,090
4. Blackfish	25,437	25,441	7,436	19,438	5,628	1,830	676	2,711	0	0	0	0	31,065	27,271	8,112	22,149
5. Bluefish	65,347	74,440	18,106	52,631	12,593	5,352	4,147	7,364	592	655	0	1,116	78,532	80,447	27,253	60,411
6. Cod	3,582	2,062	3,857	3,167	10	0	0	3	75	275	2,050	800	3,667	2,337	5,907	3,970
7. Yellowtail Flounder	13,736	10,655	7,207	10,533	0	38	0	13	22,072	14,263	65,298	33,878	35,808	24,956	72,505	44,423
8. Eels	1,379	4	35	639	1,107	65	5	392	0	0	0	0	2,986	69	40	1,032
9. Herring	19,110	30	16,811	11,984	0	0	0	0	1,144	440	0	528	1,144	470	16,811	6,142
10. Scups	170,679	181,960	166,278	172,972	44,848	33,921	9,795	29,521	2,983	14,927	0	5,970	218,510	230,808	176,073	208,464
11. Sea Bass	3,639	3,668	1,215	2,841	152	7	0	53	134	0	0	45	3,925	3,675	1,215	2,938
12. Shad	14	104	0	39	0	0	0	0	0	0	0	0	14	104	0	39
13. Sharks	146	547	0	231	0	0	46	15	0	0	0	0	146	547	46	246
14. Weakfish	65,227	35,794	31,871	44,297	5,359	2,445	1,100	2,968	1,301	23	0	441	6,660	38,262	32,971	25,964
15. Whiting	88,491	43,539	19,596	50,542	0	40	0	13	28,207	55,084	19,492	34,261	116,669	98,663	39,088	84,816
16. Squid	46,566	50,663	24,617	40,615	6,237	2,182	2,430	3,616	36,309	62,434	829	33,191	89,112	115,279	27,876	77,422
17. Ling	99	366	2,799	1,088	976	0	1,185	720	8,638	5,825	2,674	5,712	9,713	6,191	6,658	7,521
18. Angler fish	2,238	1,224	790	1,417	30	0	0	10	2,027	493	631	1,050	1,432	572	474	826
19. White Perch	5	164	60	76	0	0	0	0	0	0	0	0	5	164	60	76
20. Butterfish	41,864	0	22,864	21,576	2,110	0	2,355	1,488	398	4,492	435	1,745	44,282	4,492	25,654	24,809
21. Brill (flounder sp.)	2,221	3,069	216	1,835	390	548	0	313	70	0	0	23	2,681	3,617	216	2,171
22. Unclass food	6,917	2,193	812	3,307	0	670	472	381	233	3	0	79	7,150	2,866	1,284	3,767
											TOTAL		1,196,016	1,290,799	868,376	
														1,118,397		

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[a] Source: State of Connecticut Department of Environmental Protection Marine Fisheries Office, Waterford, Connecticut.

[b] See Figure 1 for geographical areas represented by Units I, II, and III.

Table 2. Shellfish harvest (lbs) during 1980-1982 within an 80 kilometer (50-mile) radius of the Millstone III Nuclear Power Plant

Shellfish	Connecticut				Rhode Island				New York				Total			
	1980	1981	1982	Mean	1980	1981	1982	Mean	1981	1982	1983	Mean	1980	1981	1982	Mean
Lobsters	830,220	1,010,826	1,094,102	978,382	757,900	12,100	833,333	534,444	38,700	68,000	42,600	49,766	1,626,820	363,642	1,970,035	1,320,[illegible]65
Clams (Hard, Surf, Ocean)	325,000	360,000	419,784	368,261	7,044,786	7,502,500	9,131,433	7,892,910	--	300	--	100	7,369,786	7,362,800	9,551,227	8,261,2[illegible]
Scallops (Bay and Sea)	115,669	50,000	30,000	65,223	24,000	11,000	23,350	19,450	--	9,400	8,800	6,067	139,669	70,400	62,150	90,740
Conch	147,110	472,500	134,879	251,496	98,600	135,300	123,230	119,043	5,100	5,000	1,500	3,867	250,810	612,800	259,604	374,406
Crabs (Blue, Green, Red and Rock)	920	20	32,643	11,194	103,800	55,000	181,127	113,309	--	--	--	18,333	104,720	55,020	213,770	124,503
Oysters	695,034	947,100	999,575	880,569	300	100	160	187	--	--	--	0	695,334	947,200	999,735	680,756
Mussels	--	--	--	0	98,300	33,200	240,000	123,833	--	--	--	0	98,300	33,200	240,000	123,833
TOTAL				2,555,175				8,802,176				78,133				11,175,675

Table 3. Rhode Island and New York Commercial catch by weight (lbs) of foodfish and squid in waters within a 80 kilometer (50-mile) radius of Millstone

	Rhode Island						New York						Totals			Mean
	Atlantic Ocean			Long Island Sound			Atlantic Ocean			Long Island Sound						
	1980	1981	1982	1980	1981	1982	1980	1981	1982	1980	1981	1982	1980	1981	1982	
1. Angler fish	217,000	171,000	189,900	17,900	18,100	12,300	700	9,500	8,800	20,300	21,900	22,300	255,900	220,500	233,300	236,566
2. Bluefish	138,500	126,800	274,145	6,800	20,500	11,800	--	--	--	485,500	542,200	714,100	630,800	689,500	1,000,045	773,448
3. Butterfish	515,506	345,700	831,800	49,000	42,400	46,700	4,700	--	200	65,400	50,900	47,800	634,600	437,000	926,500	666,033
4. Cod	414,400	277,100	210,400	17,000	14,200	27,200	6,200	2,800	3,500	27,300	16,800	14,900	464,900	310,900	256,000	343,933
5. Eels	23,400	800	1,500	--	--	--	--	--	--	1,000	1,400	1,700	24,400	2,700	3,200	10,100
6. Flounder	5,471,700	5,019,600	6,022,600	648,100	842,300	757,300	52,800	16,000	251,900	619,700	906,400	821,600	6,792,300	6,784,300	7,853,400	7,143,333
7. Mackeral	298,100	289,400	215,200	2,500	1,100	1,200	--	--	--	96,600	68,700	127,700	397,200	359,200	344,100	366,833
8. Haddock	16,100	1,000	1,000	--	--	--	--	--	100	11,100	--	--	27,200	1,000	1,100	9,767
9. Hake	347,600	237,500	563,800	53,300	35,700	78,100	--	--	400	41,200	32,200	16,000	442,100	305,400	658,300	468,600
10. Herring	2,202,100	1,497,800	2,961,100	189,000	--	26,000	--	--	--	10,000	2,200	5,700	2,401,100	1,500,000	2,992,800	2,297,967
11. Ocean Pout	95,600	120,100	--	2,000	--	--	--	--	--	--	--	--	97,600	120,100	0	72,567
12. Pollock	11,900	6,700	3,700	100	200	100	700	3,600	900	1,500	300	500	14,200	10,800	5,200	10,067
13. Scup	3,758,300	3,341,700	3,847,000	54,700	254,500	86,000	200	--	400	441,300	607,000	408,300	4,254,500	4,203,200	4,341,700	4,266,467
14. Sea Bass	52,300	42,900	83,000	1,200	400	1,700	--	--	--	22,400	33,000	20,600	75,900	76,300	105,300	85,833
15. Sea Trout	222,100	219,800	157,800	200	--	300	--	--	--	412,600	325,600	230,800	634,900	545,400	388,900	523,067
16. Shad	2,100	33,200	76,700	--	--	--	--	--	--	8,900	400	6,900	11,000	33,600	83,600	42,733
17. Striped Bass	18,600	174,100	136,000	200	100	100	--	--	--	244,900	318,600	161,200	263,700	492,800	174,900	310,467
18. Swordfish	2,000	--	--	--	--	--	--	900	--	--	--	--	2,000	900	0	967
19. Tautog	18,000	17,300	24,700	--	--	--	--	--	--	6,200	7,500	8,200	24,200	24,900	32,900	27,333
20. Tilefish	800	1,200	3,100	--	--	--	--	200	--	300	100	--	1,100	1,500	3,100	1,900
21. Tuna	200	101,200	4,600	--	--	--	27,100	127,700	26,022	4,800	6,900	6,000	32,100	235,800	36,622	101,507
22. Whiting	2,873,100	2,358,200	3,733,600	841,600	1,134,000	915,670	6,600	2,600	3,400	350,800	231,200	122,400	4,072,100	3,726,000	4,774,800	4,190,967
23. Finfish-Food	3,177,300	4,184,400	3,753,000	785,200	1,729,000	476,900	--	--	--	--	--	--	3,966,600	5,913,400	4,229,800	6,004,067
											TOTAL		25,5204001	25,995,100	29,445,567	
											MEAN			26,653,689		

APPENDIX J

DESCRIPTION OF POTENTIAL OFFSITE DAMAGES FROM EARTHQUAKES OF VARIOUS INTENSITIES, ACCORDING TO THE MODIFIED MERCALLI INTENSITY SCALE OF 1931

APPENDIX J

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 excitement, a few ran outdoors.
e. Buildings trembled throughout.
f. Dishes, glassware broken to some extent.
g. Windows cracked in same 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.

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.

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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.

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 greatly.
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 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 5.15 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 Millstone site meteorological 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 5.16) 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							
		M1A	M1B	M2A	M2B	M4	M6	M7	M12
1. Early fatalities with supportive medical treatment (persons)	Evac-Reloc	9(1)*	0	2(-1)	7(0)	1(1)	9(0)	0	0
	Late Reloc	**	***	6(1)	1(1)	3(0)	2(1)	1(0)	***
2. Population receiving in excess of 200 rems total marrow dose from early exposure (persons)	Evac-Reloc	1(3)	7(0)	3(2)	4(2)	1(3)	5(2)	6(1)	0
	Late Reloc	**	***	2(3)	2(3)	3(3)	1(3)	4(2)	***
3. Early injuries (persons)	Evac-Reloc	1(3)	9(0)	4(2)	6(2)	1(3)	6(2)	1(2)	0
	Late Reloc	**	***	1(3)	2(3)	2(3)	1(3)	5(2)	***
4. Delayed cancer fatalities (excluding thyroid) (persons)	Evac-Reloc	1(3)	2(2)	1(3)	3(3)	2(3)	1(3)	7(2)	2(-2)
	Late Reloc	**	***	1(3)	3(3)	2(3)	1(3)	9(2)	***
5. Delayed thyroid cancer fatalities (persons)	Evac-Reloc	5(2)	9(1)	7(2)	9(2)	5(2)	3(2)	2(2)	3(-2)
	Late Reloc	**	***	7(2)	9(2)	5(2)	3(2)	2(2)	***
6. Total person-rems	Evac-Reloc	2(7)	5(6)	3(7)	3(7)	3(7)	2(7)	2(7)	5(2)
	Late Reloc	**	***	3(7)	3(7)	4(7)	2(7)	2(7)	***
7. Cost of offsite mitigation measures (1980 $)	Evac-Reloc	2(9)	2(8)	2(9)	2(9)	2(9)	2(9)	1(9)	2(3)
	Late Reloc	**	***	2(9)	2(9)	2(9)	2(9)	1(9)	***

See footnotes at end of table.

Table K.1 (Continued)

Consequence Category	Offsite Emergency Response Mode	Release Categories							
		M1A	M1B	M2A	M2B	M4	M6	M7	M12
8. Land area for long-term interdiction (m^2)†	Evac-Reloc	1(8)	1(7)	1(8)	1(8)	1(8)	1(8)	1(8)	0
	Late Reloc	**	***	1(8)	1(8)	1(8)	1(8)	1(8)	***

*9(1) = 9×10^1 = 90.

**These release categories are initiated by plant internal causes; therefore, the Late Reloc mode does not apply.

***This release category has a probability less than 10^{-9} per reactor-year to be initiated by severe earthquakes; it is not analyzed with the Late Reloc mode for its insignificant contribution to risks because of its low probability.

†Above 2.6 million m^2 equals 1 mi^2.

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

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 RISK 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 (that is, 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 release categories initiated by severe earthquakes were analyzed with the assumption of late relocation (Late Reloc) mode of offsite emergency response (see Section 5.9.4.5(2) and Table 5.18). 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 5.18). A separate display of the contributions to the overall results (presented in the 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 80 km (50 miles) from Millstone 3 are also presented.

Figures L.1 through L.13 display the breakdowns of each of the graphical plots presented in Figures 5.7 through 5.15 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.13, the graphical plots of Figures 5.7 through 5.15 are reproduced for easy reference.

Tables L.1a and L.1b provide a breakdown of each category of risk shown in Table 5.20 into the two components as stated above. From these tables it is apparent that the release categories initiated by events other than severe earthquakes are the dominant contributors to the risks of both early fatality (with supportive or minimal medical treatment) and latent cancer fatality.

Table L.2 shows the contributions to the risk of early fatality with supportive medical treatment from the spatial intervals within 80 km (50 miles) of the plant. Contributions from each spatial interval are also broken down into component contributions ascribed to severe earthquakes and the other causes.

Table L.3 shows results for early fatality in a manner similar to that in Table L.2, but with minimal medical treatment.

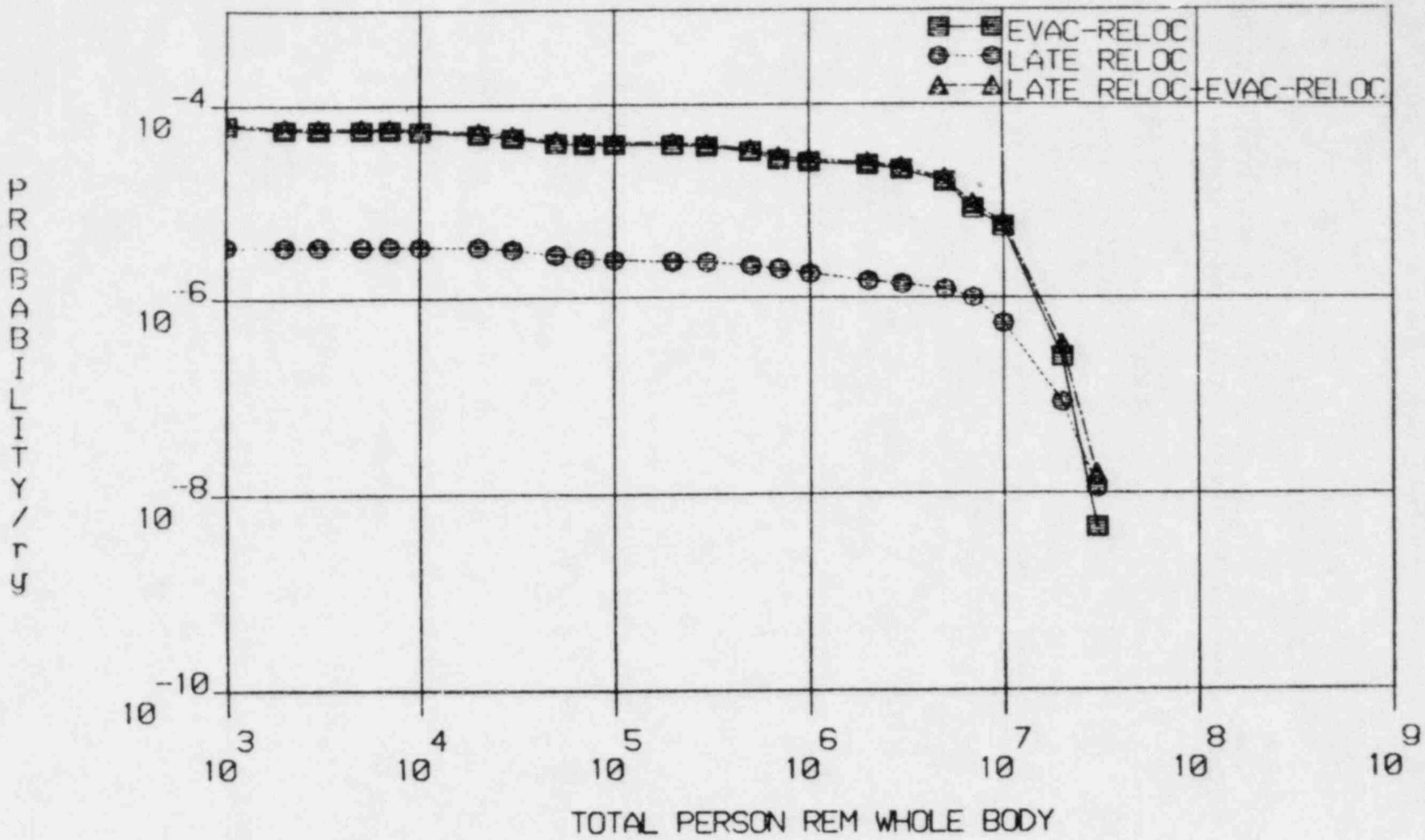

Figure L.1 Probability distribution of population exposure within 50 miles

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

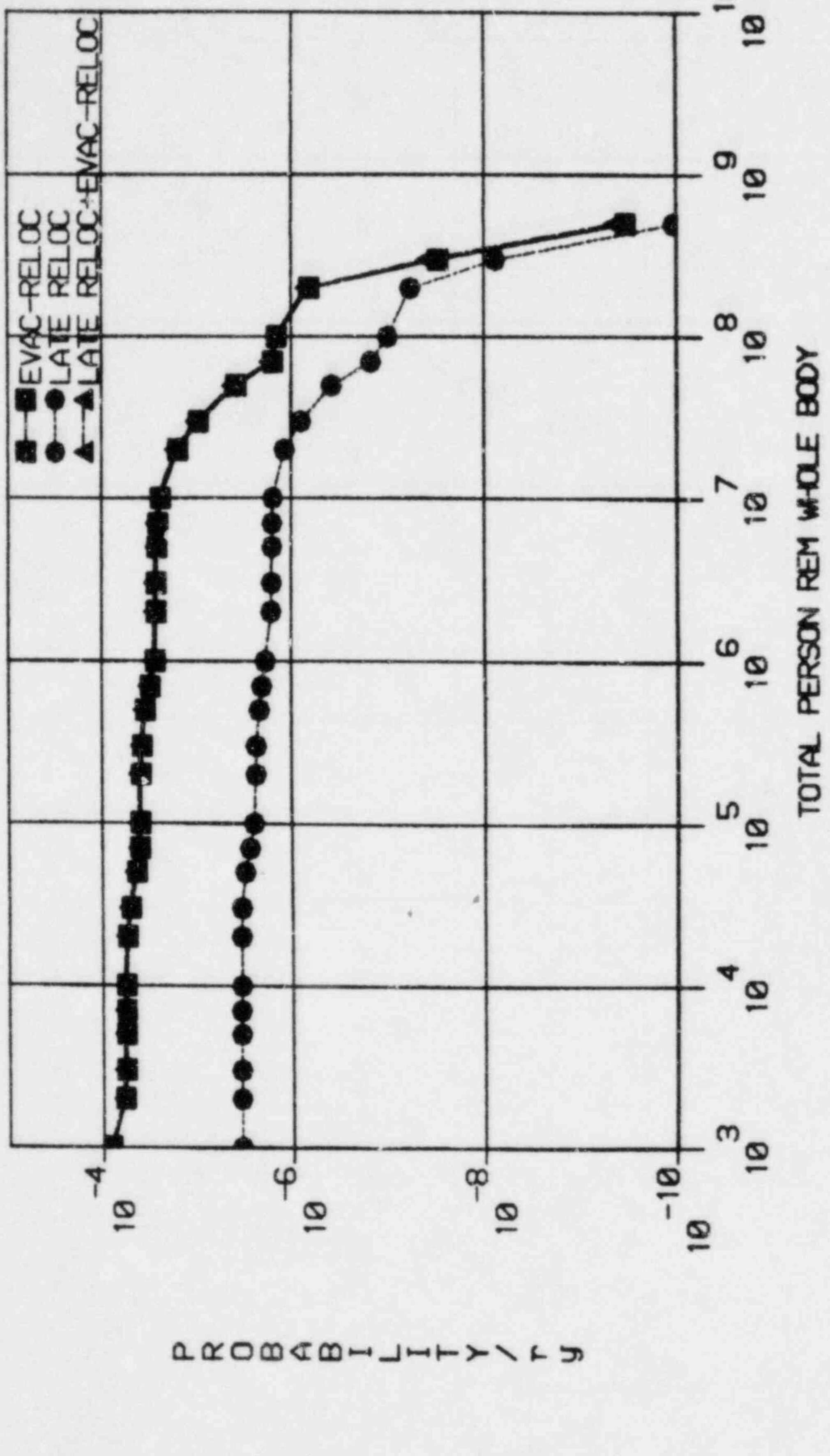

Figure L.2 Probability distribution of population exposure, entire region

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

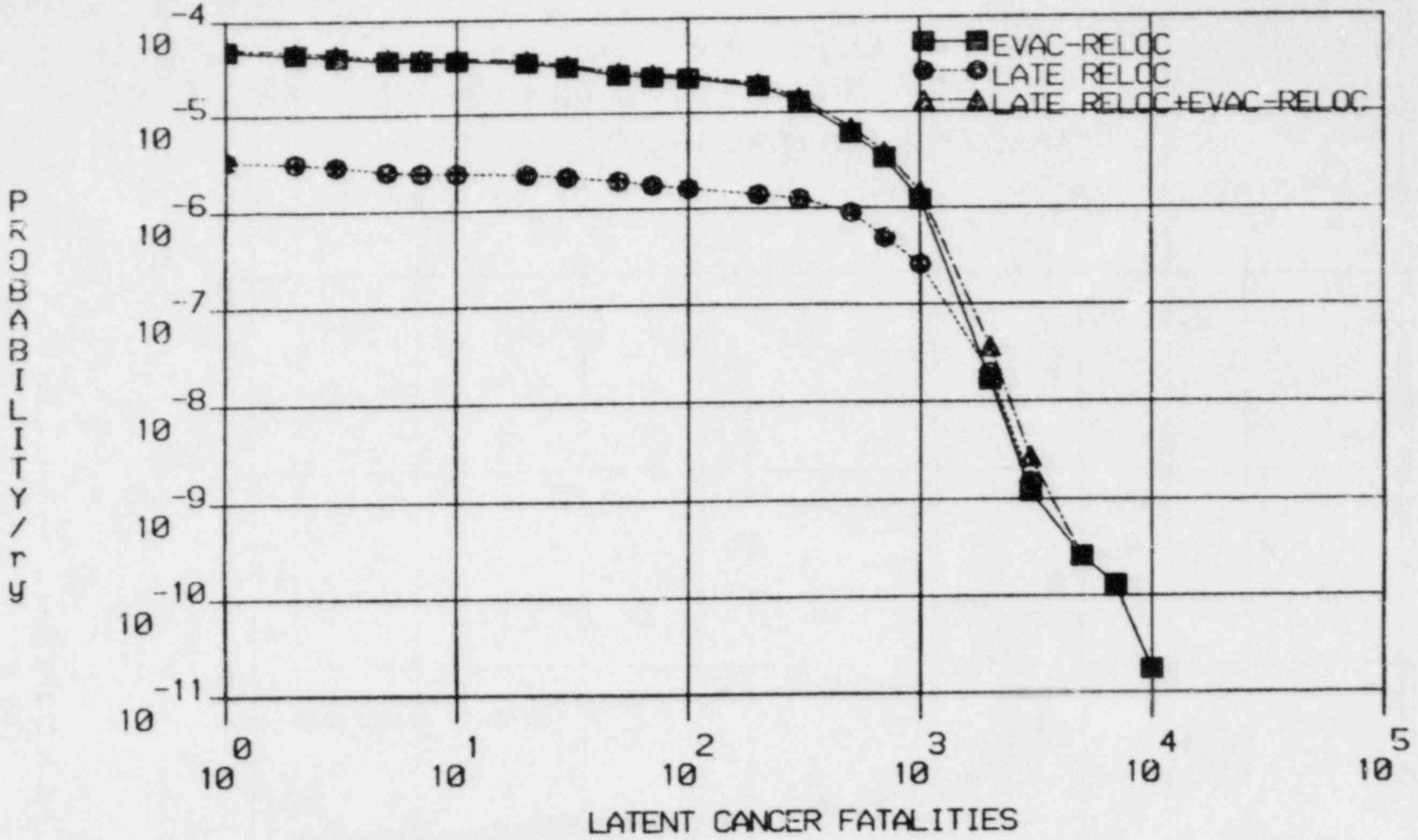

Figure L.3 Probability distribution of latent cancer fatalities, excluding thyroid, within 50 miles

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

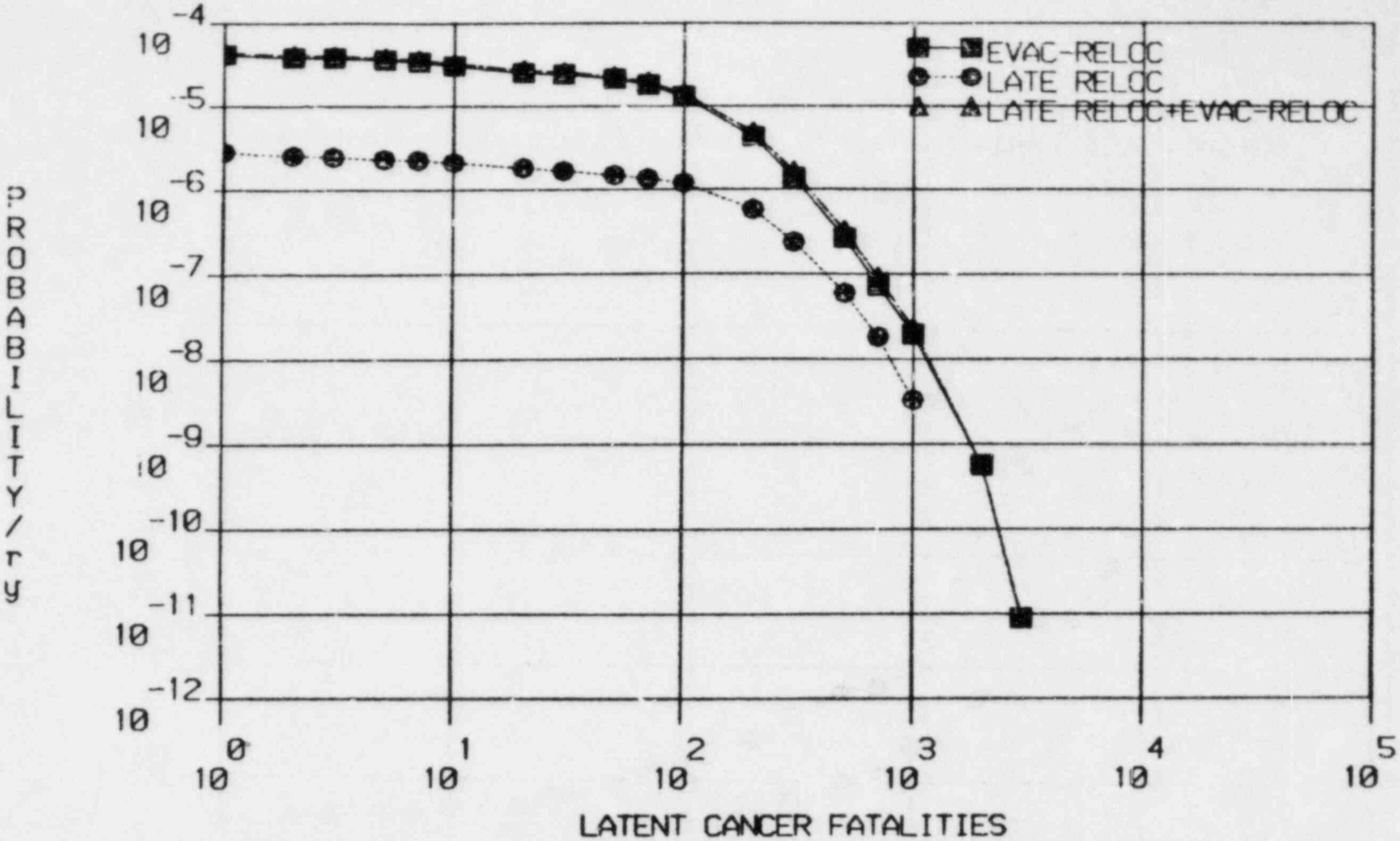

Figure L.4 Probability distribution of thyroid cancer fatalities within 50 miles

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

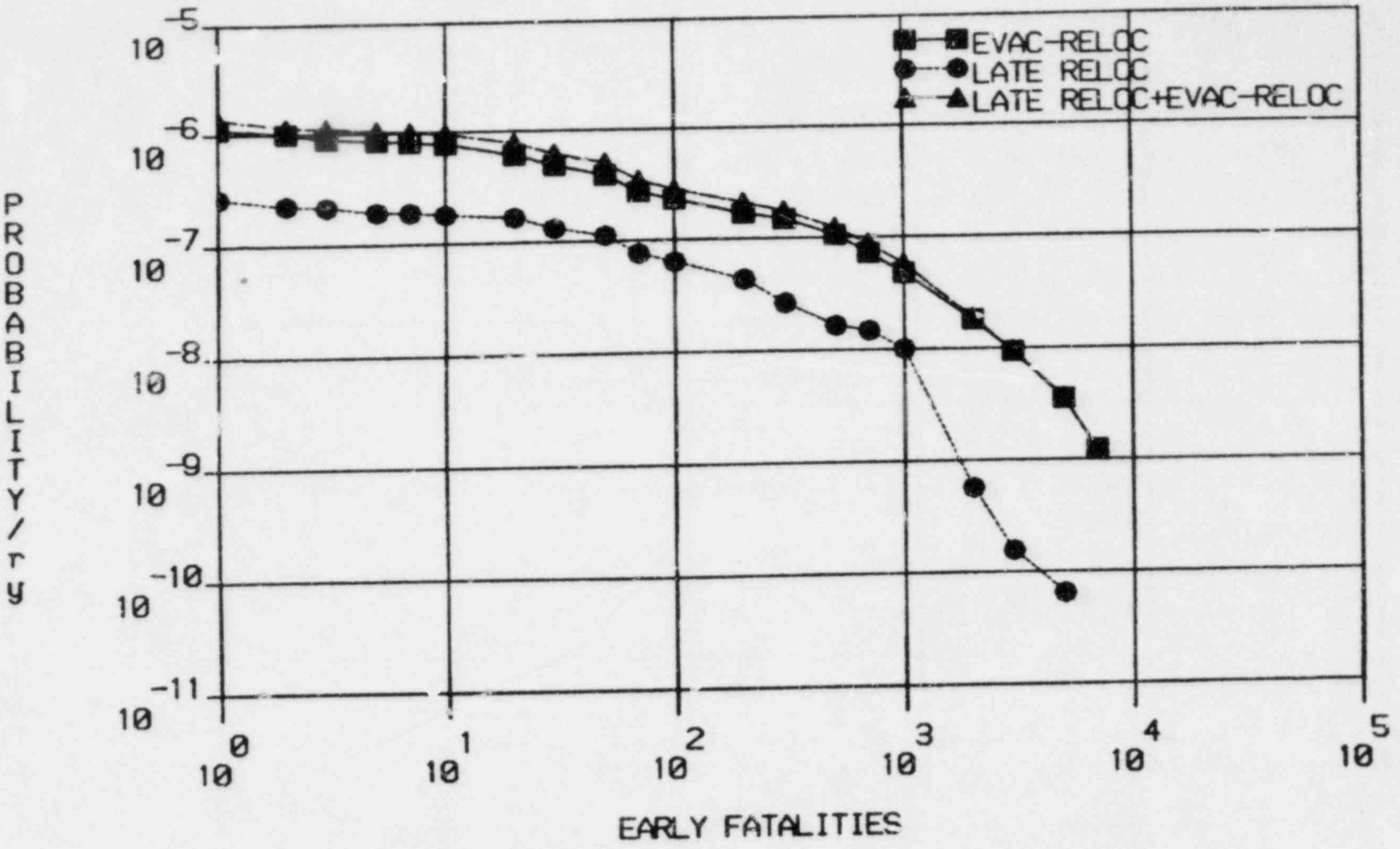

Figure L.5 Probability distribution of early fatality with supportive medical treatment

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

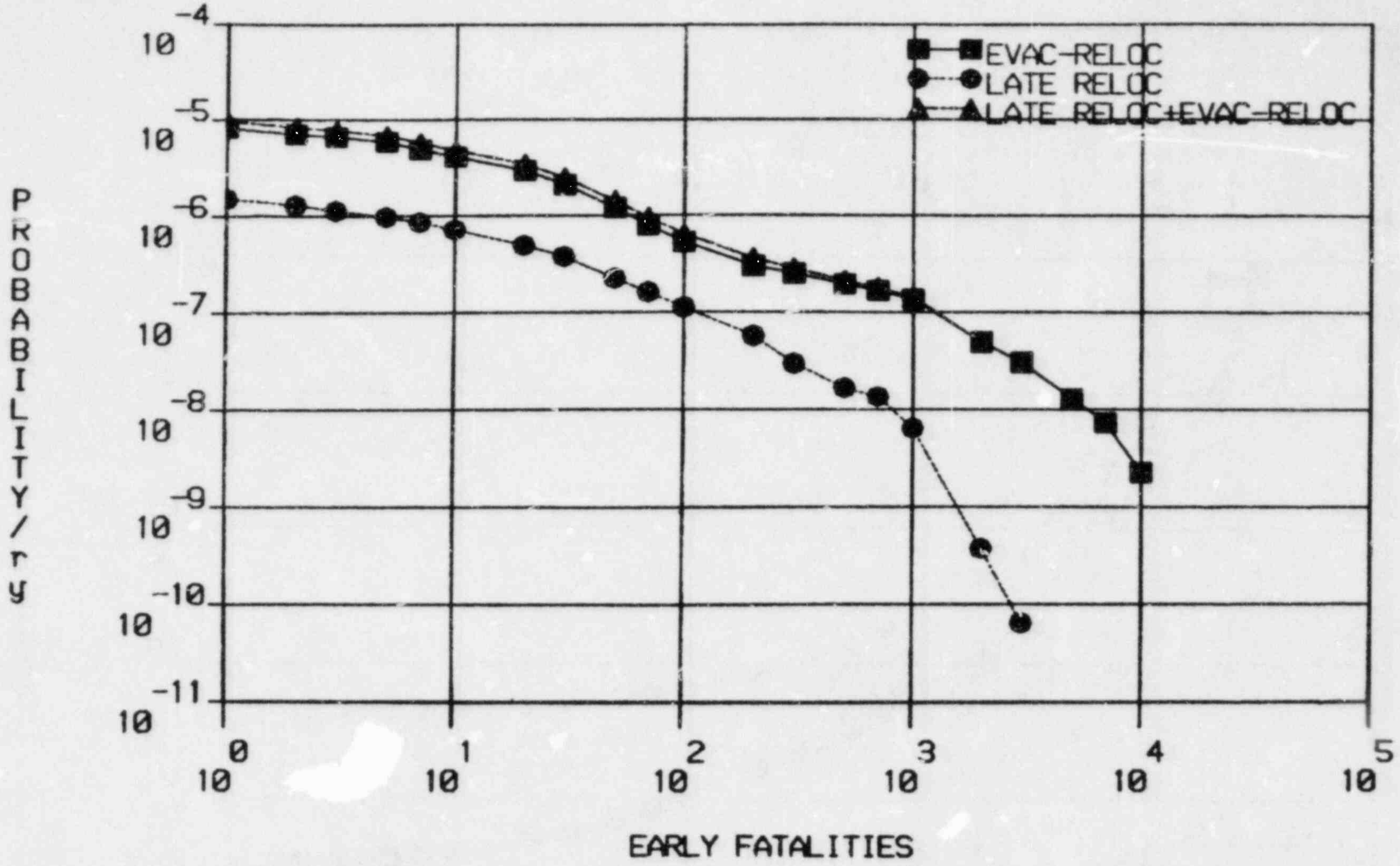

Figure L.6 Probability distribution of early fatalities with minimal medical treatment

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

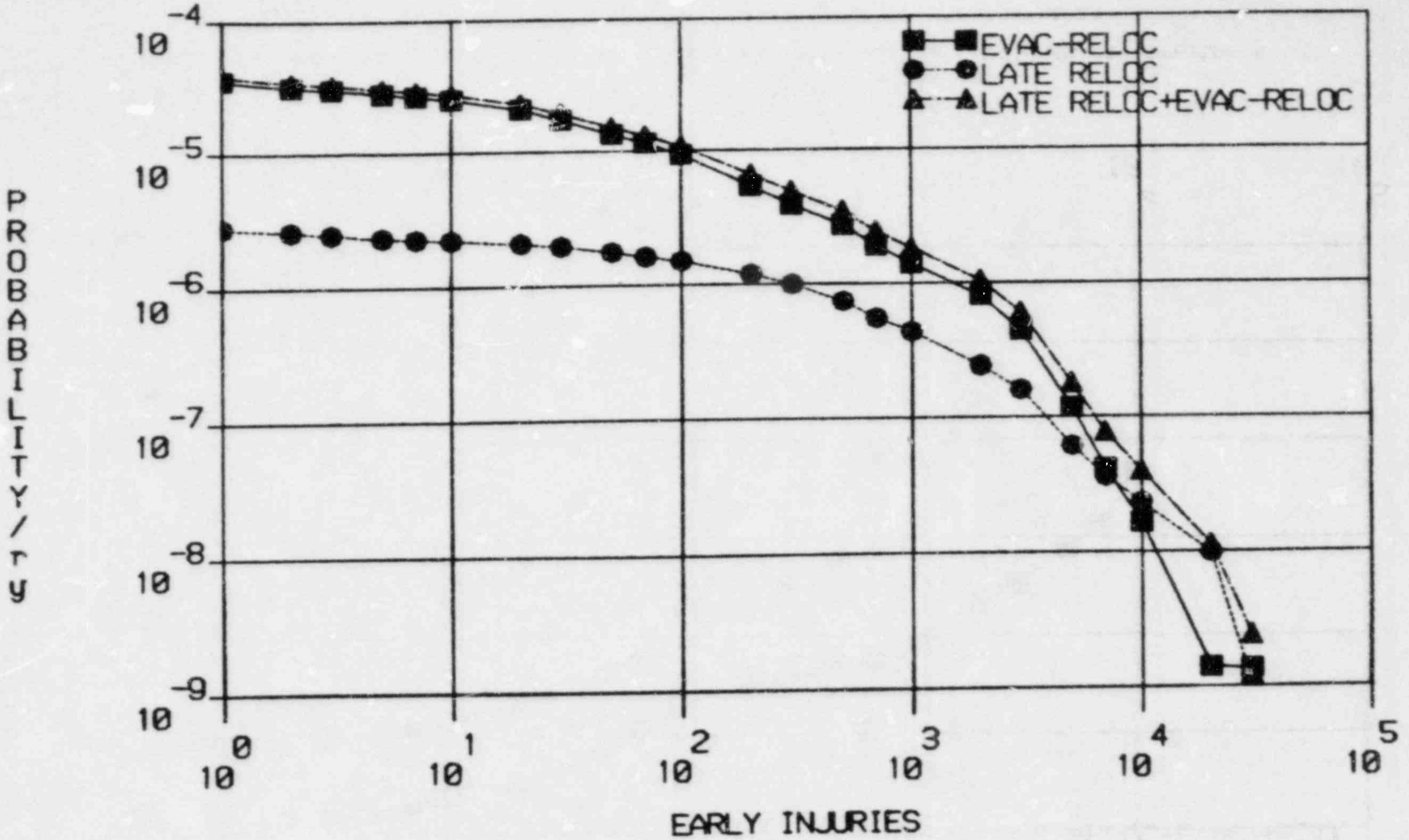

Figure L.7 Probability distribution of early injuries

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

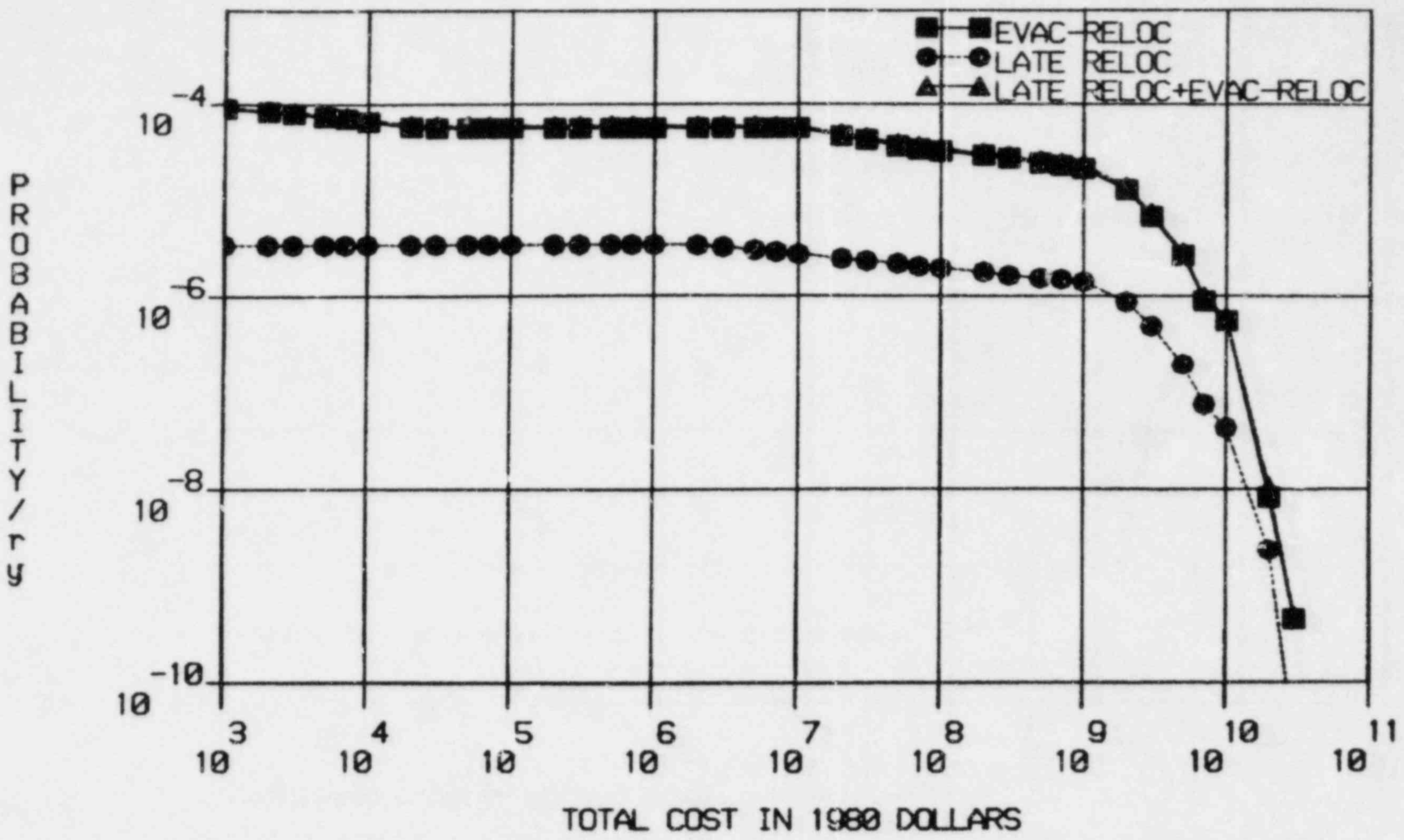

Figure L.8 Probability distribution of mitigation measures cost

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

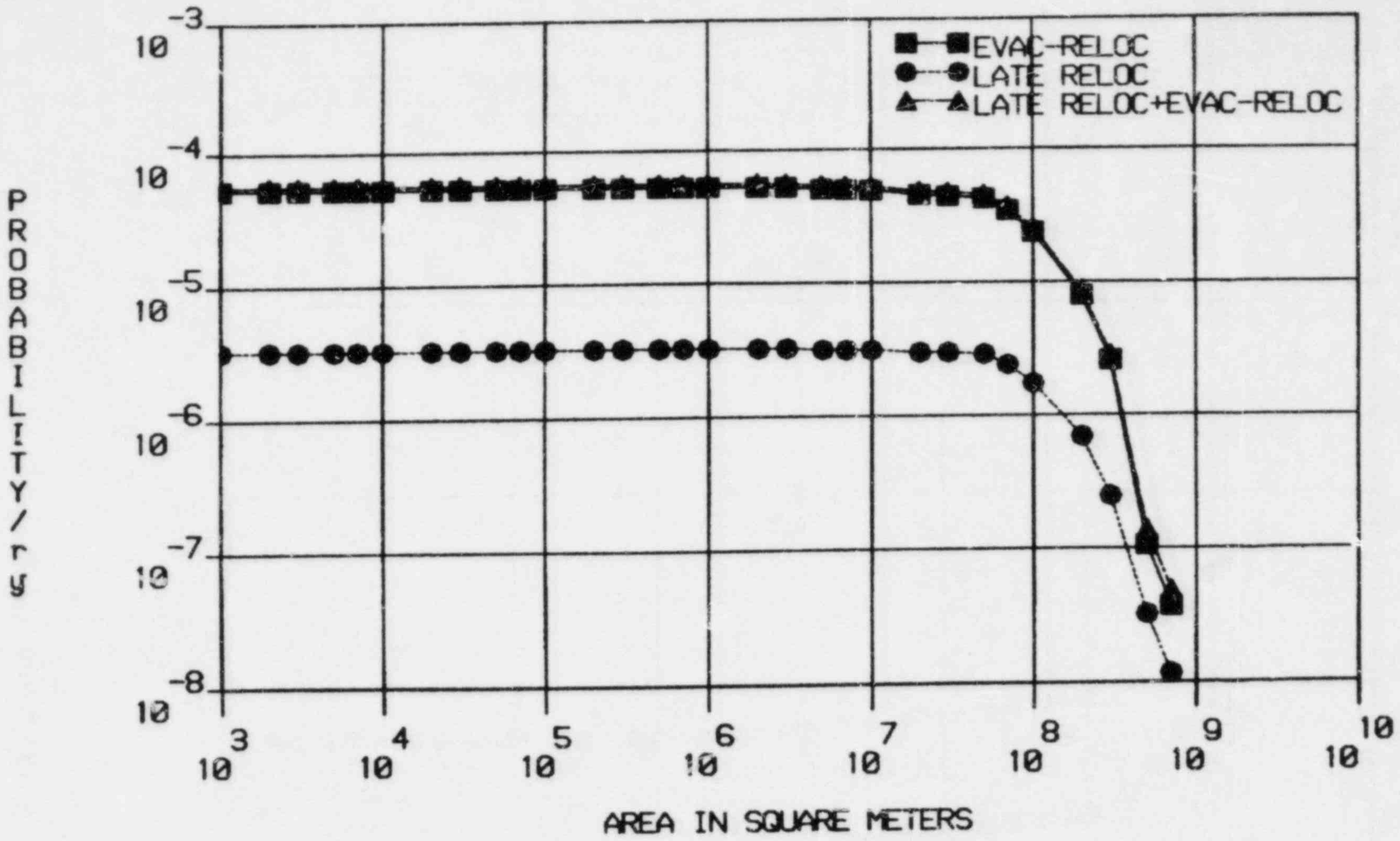

Figure L.9 Probability distribution of land area interdiction

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

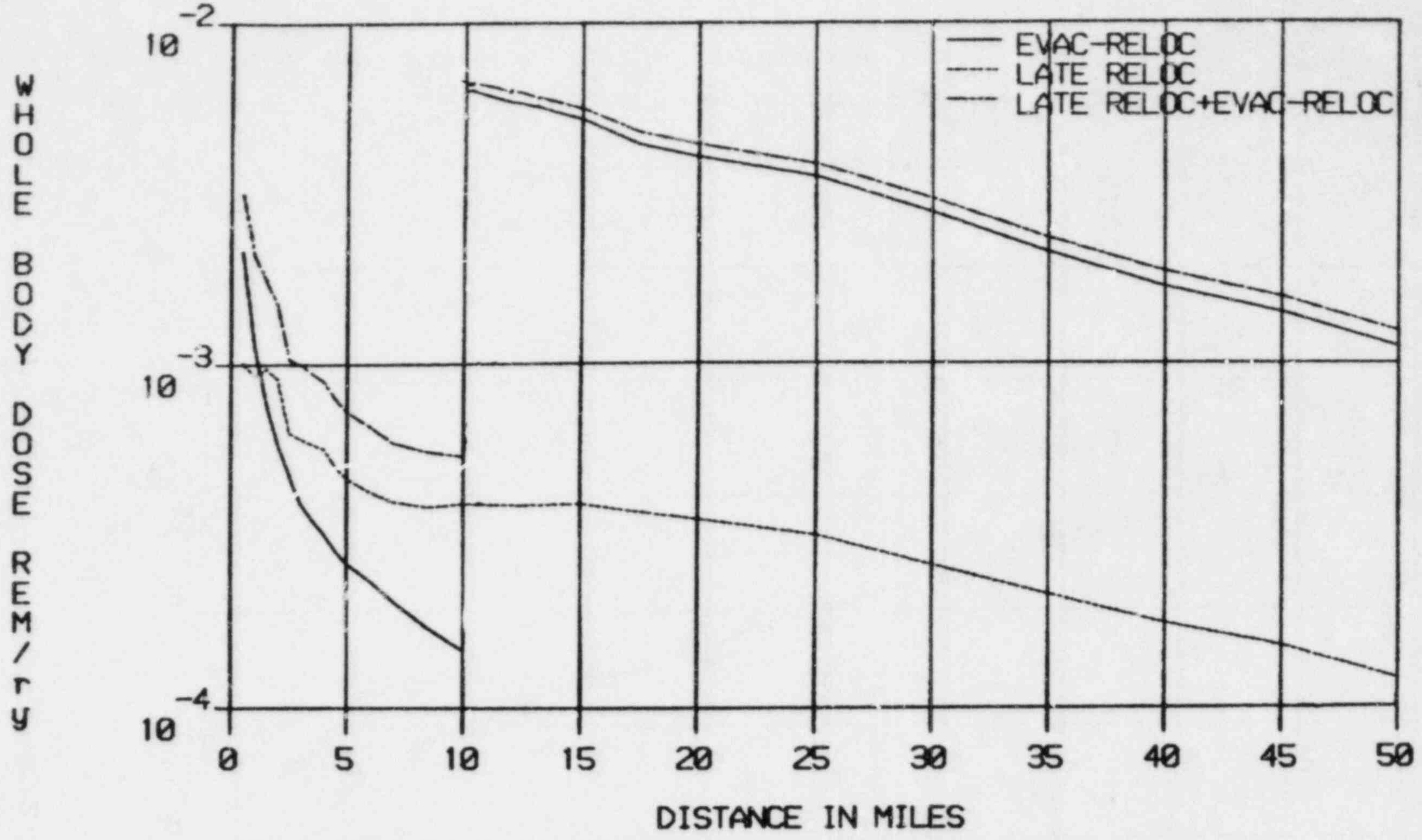

Figure L.10 Individual risk of downwind dose versus distance

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

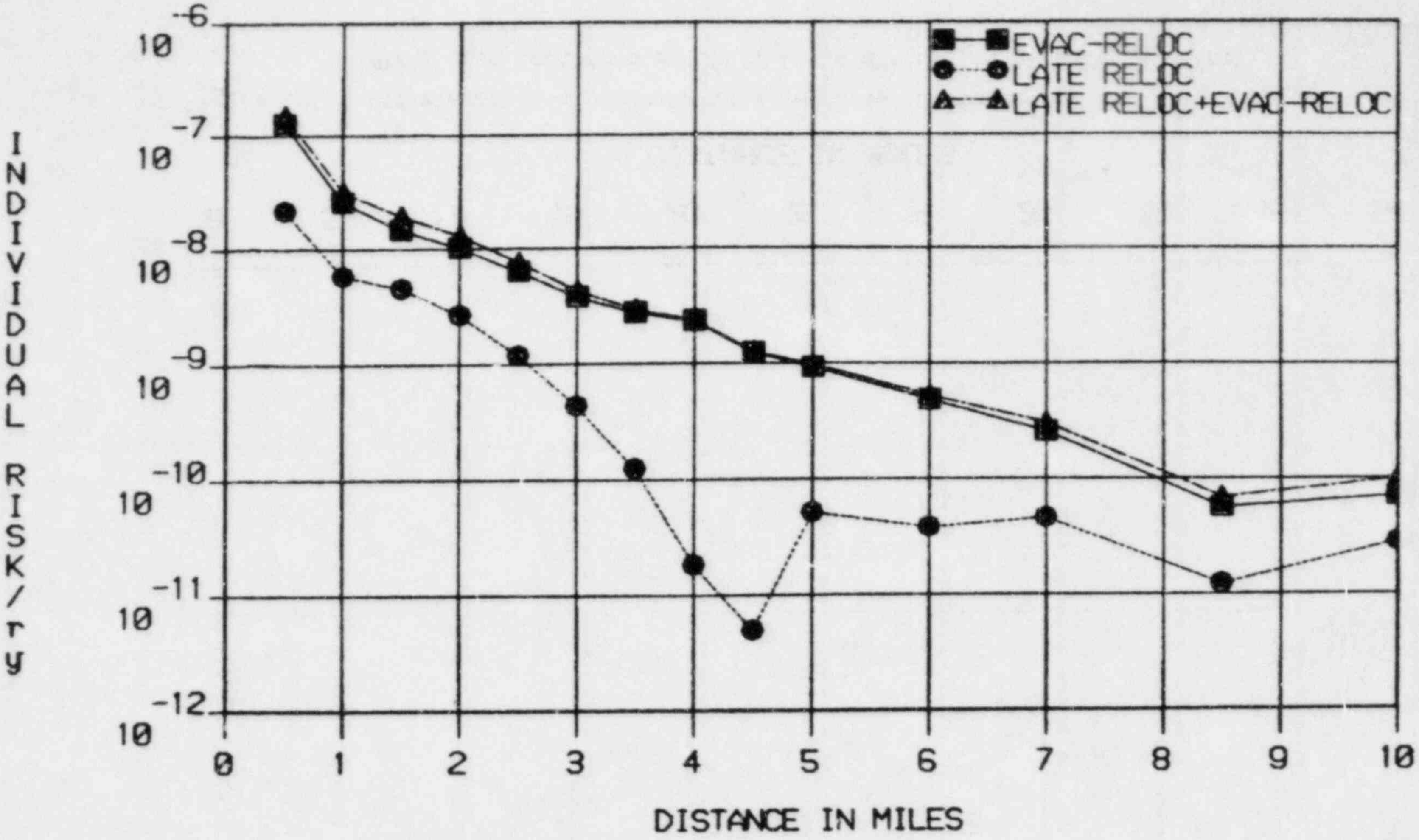

Figure L.11 Individual risk of early fatality with supportive medical treatment versus distance
NOTE: See Section 5.9.4.5(7) for discussion of uncertainties.

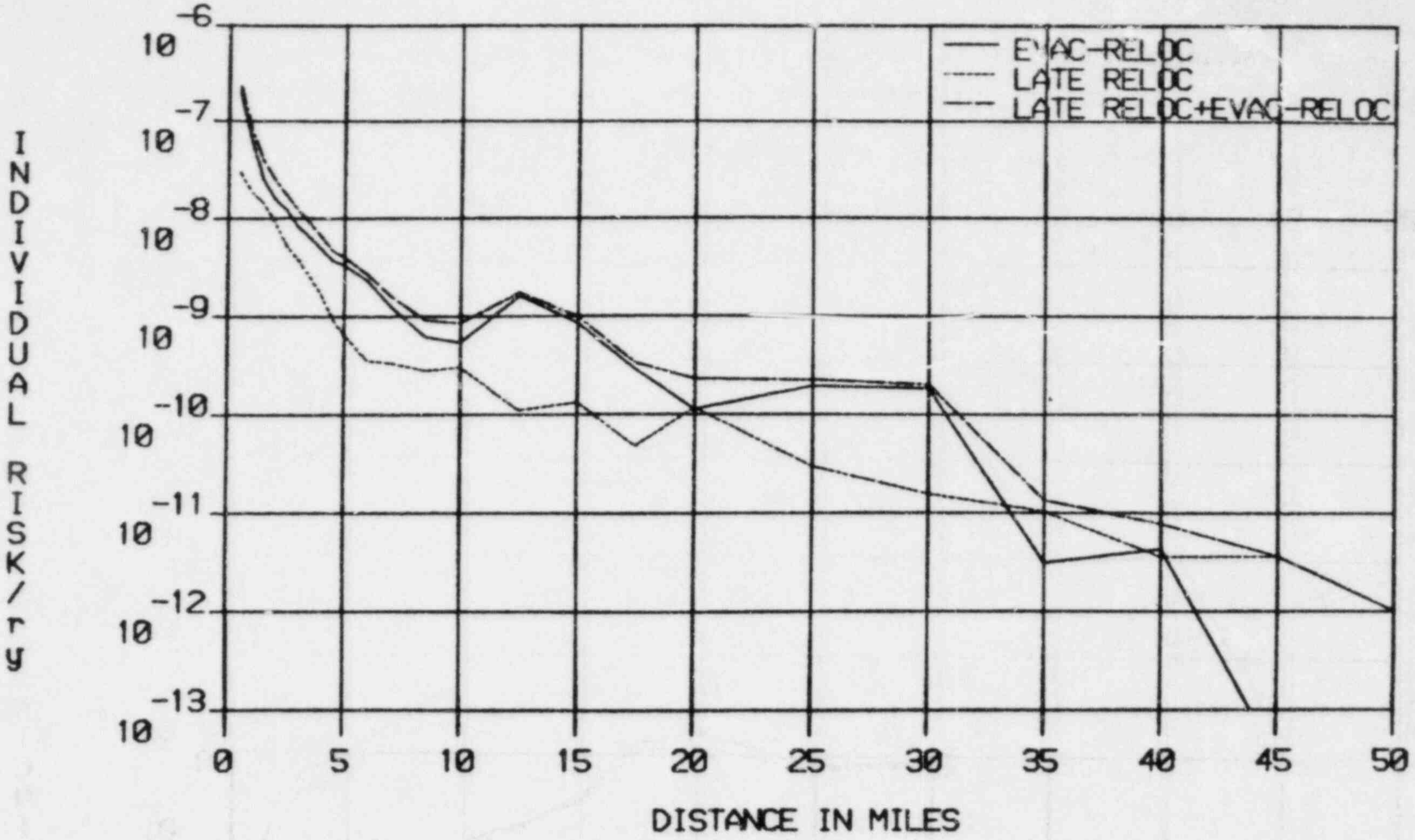

Figure L.12 Individual risk of early fatality with minimal medical treatment versus distance

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

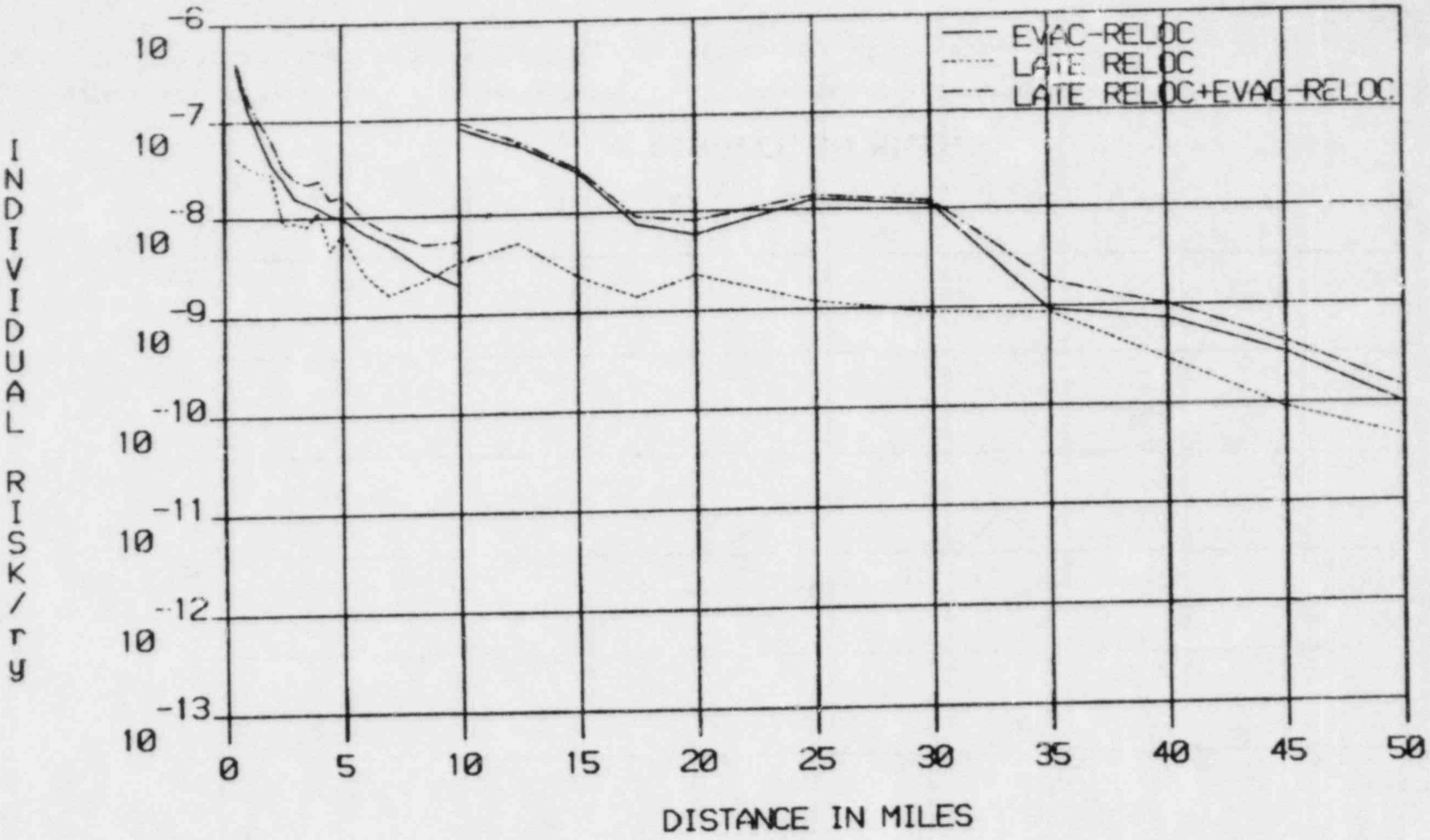

Figure L.13 Individual risk of early injury versus distance

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

Table L.1a Societal risks within 80 km (50 miles) of Millstone 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)**	3(-5)	2(-4)
2. Early fatalities with minimal medical treatment (persons)	6(-4)	2(-4)	8(-4)
3. Early injuries (persons)	7(-3)	2(-3)	9(-3)
4. Latent cancer fatalities (excluding thyroid) (persons)	1(-2)	1(-3)	1(-2)
5. Latent thyroid cancer fatalities (persons)	3(-3)	3(-4)	3(-3)
6. Total person-rems	2(2)	2(1)	2(2)
7. Cost of offsite mitigation measures (1980 $)	3(4)	2(3)	3(4)
8. Land area for long-term interdiction (m^2)***	4(3)	2(2)	4(3)

*See Section 5.9.4.5(2).

**2(-4) = 2 × 10^{-4} = 0.0002.

***About 2.6 million m^2 equals 1 mi^2.

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 entire region of Millstone 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)**	3(-5)	2(-4)
2. Early fatalities with minimal medical treatment (persons)	6(-4)	2(-4)	8(-4)
3. Early injuries (persons)	7(-3)	2(-3)	9(-3)
4. Latent cancer fatalities (excluding thyroid) (persons)	4(-2)	3(-3)	4(-2)
5. Latent thyroid cancer fatalities (persons)	1(-2)	8(-4)	1(-2)
6. Total person-rems	1(3)	7(1)	1(3)
7. Cost of offsite mitigation measures (1980 $)	7(4)	5(3)	8(4)
8. Land area for long-term interdiction (m^2)***	4(3)	3(2)	4(3)

*See Section 5.9.4.5(2).

**2(-4) = 2 × 10^{-4} = 0.0002.

***About 2.6 million m^3 equals 1 mi^2.

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 for spatial intervals within 80 km (50 miles) of Millstone 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***	2(-5)†	4(-6)	2(-5)
0.5 - 1.0	8(-6)	2(-6)	1(-5)
1.0 - 1.5††	3(-5)	1(-5)	4(-5)
1.5 - 2.0	3(-5)	7(-6)	4(-5)
2.0 - 2.5	2(-5)	4(-6)	2(-5)
2.5 - 3.0	1(-5)	2(-6)	1(-5)
3.0 - 3.5	3(-5)	1(-6)	3(-5)
3.5 - 4.0	3(-5)	2(-7)	3(-5)
4.0 - 4.5	1(-5)	5(-8)	1(-5)
4.5 - 5.0	1(-5)	6(-7)	1(-5)
5.0 - 6.0	5(-6)	4(-7)	5(-6)
6.0 - 7.0	3(-6)	5(-7)	3(-5)
7.0 - 8.5	1(-6)	3(-7)	1(-6)
8.5 - 10.0	2(-6)	7(-7)	3(-6)
10.0 - 12.5	1(-6)	0	1(-6)
12.5 - 15.0	3(-6)	5(-7)	3(-6)
15.0 - 17.5	0	0	0
17.5 - 20.0	0	1(-7)	1(-7)
20.0 - 25.0	0	0	0
25.0 - 30.0	0	0	0
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)	3(-5)	2(-4)

*See Section 5.9.4.5(2).

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

***This circular zone includes the site exclusion area.

†2(-5) = 2×10^{-5} = 0.00002.

††93% of the area of this annulus is included within an annulus 1 mile wide outside 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 80 km (50 miles) of Millstone 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***	4(-5)†	5(-6)	5(-5)
0.5 - 1.0	2(-5)	7(-6)	3(-5)
1.0 - 1.5††	5(-5)	3(-5)	8(-5)
1.5 - 2.0	4(-5)	2(-5)	6(-5)
2.0 - 2.5	4(-5)	2(-5)	6(-5)
2.5 - 3.0	3(-5)	1(-5)	4(-5)
3.0 - 3.5	6(-5)	2(-5)	8(-5)
3.5 - 4.0	5(-5)	2(-5)	7(-5)
4.0 - 4.5	4(-5)	1(-5)	5(-5)
4.5 - 5.0	4(-5)	3(-6)	5(-5)
5.0 - 6.0	2(-5)	4(-6)	2(-5)
6.0 - 7.0	2(-5)	4(-6)	2(-5)
7.0 - 8.5	1(-5)	6(-6)	2(-5)
8.5 - 10.0	1(-5)	8(-6)	2(-5)
10.0 - 12.5	5(-5)	3(-6)	5(-5)
12.5 - 15.0	3(-5)	5(-6)	4(-5)
15.0 - 17.5	1(-5)	2(-6)	1(-5)
17.5 - 20.0	6(-6)	6(-6)	1(-5)
20.0 - 25.0	1(-5)	2(-6)	1(-5)
25.0 - 30.0	2(-5)	1(-6)	2(-5)
30.0 - 35.0	9(-7)	3(-6)	4(-6)
35.0 - 40.0	1(-6)	1(-6)	2(-6)
40.0 - 45.0	2(-8)	2(-6)	2(-6)
45.0 - 50.0	5(-8)	7(-7)	8(-7)
Total	6(-4)	2(-4)	8(-4)

*See Section 5.9.4.5(2).

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

***This circular zone includes the site exclusion area.

†4(-5) = 4 × 10^{-5} = 0.00004.

††93% of the area of this annulus is included within an annulus 1 mile wide outside 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 the Evac-Reloc offsite emergency response mode (see Section 5.9.4.5(2) and Table 5.18). 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 (that is, the societal risks) resulting from this alternative evaluation are presented below.

Tables M.1a and M.1b are similar to Tables L.1a and L.1b, respectively, in Appendix L. The numbers in the second columns of Tables M.1a and M.1b 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 L.1b 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 5.20) from release categories initiated by all causes, and are the sums of the numbers in the preceding columns for each risk type.

In Tables M.1a and M.1b, the numbers in parentheses below the entry for each type of risk (health effects and population exposure only) are the ratios of the risk estimates in these tables to the corresponding risk estimate in Tables L.1a and L.1b. 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 the emergency response mode. The risk of early fatality is about 2 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 internal events, the overall risk of early fatality with supportive or minimal medical treatment is higher by a factor of 2 for the choice of the Early Reloc over the Evac-Reloc mode. The other types of risks in Tables M.1a and M.1b are less sensitive to the choice between the Early Reloc and Evac-Reloc modes.

Tables M.2 and M.3, respectively, display the contributions to the risks of early fatality with supportive medical treatment and with minimal medical treatment, for the spatial intervals within 80 km (50 miles) of the plant.

Table M.1a Societal risks within 50 miles (80-km) of Millstone 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)	4(-4)** (2)	3(-5)	4(-4) (2)
2.	Early fatalities with minimal medical treatment (persons)	8(-4) (1)	2(-4)	8(-4) (1)
3.	Early injuries (persons)	7(-3) (1)	2(-3)	9(-3) (1)
4.	Latent cancer fatalities, excluding thyroid (persons)	1(-2) (1)	1(-3)	1(-2) (1)
5.	Latent thyroid cancer fatalities (persons)	4(-3) (1)	3(-4)	4(-3) (1)
6.	Total person-rems	2(2) (1)	2(1)	2(2) (1)
7.	Cost of offsite mitigation measures (1980 $)	3(4) (1)	2(3)	3(4) (1)
8.	Land area for long-term interdiction (m^2)***	4(3) (1)	2(2)	4(3)

*See Section 5.9.4.5(2).

**4(-4) = 4 x 10^{-4} = 0.0004

***About 2.6 million m^2 equals 1 mi^2.

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 Millstone 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)	4(-4)** (2)	3(-5)	4(-4) (2)
2.	Early fatalities with minimal medical treatment (persons)	8(-4) (1)	2(-4)	8(-4) (1)
3.	Early injuries (persons)	7(-3) (1)	2(-3)	9(-3) (1)
4.	Latent cancer fatalities, excluding thyroid (persons)	4(-2) (1)	3(-3)	4(-2) (1)
5.	Latent thyroid cancer fatalities (persons)	1(-2) (1)	8(-4)	1(-2) (1)
6.	Total person-rems	1(3) (1)	7(1)	1(3) (1)
7.	Cost of offsite mitigation measures (1980 $)	7(4) (1)	5(3)	8(4) (1)
8.	Land area for long-term interdiction (m^2)***	4(3) (1)	3(2)	4(3) (1)

*See Section 5.9.4.5(2).
**4(-4) = 4 x 10^{-4} = 0.0004
***About 2.6 million m^2 equals 1 mi^2.

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 80 km (50 miles) of the Millstone 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***	5(-5)†	4(-6)	5(-5)
0.5 - 1.0	2(-5)	2(-6)	2(-5)
1.0 - 1.5††	5(-5)	1(-5)	6(-5)
1.5 - 2.0	4(-5)	7(-6)	5(-5)
2.0 - 2.5	3(-5)	4(-6)	3(-5)
2.5 - 3.0	2(-5)	2(-6)	2(-5)
3.0 - 3.5	5(-5)	1(-6)	5(-5)
3.5 - 4.0	4(-5)	2(-7)	4(-5)
4.0 - 4.5	2(-5)	5(-8)	3(-5)
4.5 - 5.0	2(-5)	6(-7)	2(-5)
5.0 - 6.0	7(-6)	4(-7)	7(-6)
6.0 - 7.0	2(-6)	5(-7)	3(-6)
7.0 - 8.5	5(-7)	3(-7)	8(-7)
8.5 - 10.0	0	7(-7)	7(-7)
10.0 - 12.5	1(-6)	0	1(-6)
12.5 - 15.0	3(-6)	5(-7)	4(-6)
15.0 - 17.5	0	0	0
17.5 - 20.0	0	1(-7)	1(-7)
20.0 - 25.0	0	0	0
25.0 - 30.0	0	0	0
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	4(-4)	3(-5)	4(-4)

*See Section 5.9.4.5(2).

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

***This circular zone includes the site exclusion area.

†5(-5) = 5 x 10^{-5} = 0.00005.

††93% of the area of this annulus is included within an annulus 1 mile wide outside 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 80 km (50 miles) of the Millstone 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***	7(-5)†	5(-6)	8(-5)
0.5 - 1.0	4(-5)	7(-6)	5(-5)
1.0 - 1.5††	1(-4)	3(-5)	1(-4)
1.5 - 2.0	7(-5)	2(-5)	9(-5)
2.0 - 2.5	5(-5)	2(-5)	7(-5)
2.5 - 3.0	4(-5)	1(-5)	6(-5)
3.0 - 3.5	7(-5)	2(-5)	9(-5)
3.5 - 4.0	6(-5)	2(-5)	8(-5)
4.0 - 4.5	5(-5)	1(-5)	6(-5)
4.5 - 5.0	4(-5)	8(-6)	5(-5)
5.0 - 6.0	2(-5)	4(-6)	2(-5)
6.0 - 7.0	1(-5)	4(-6)	1(-5)
7.0 - 8.5	9(-6)	6(-6)	2(-5)
8.5 - 10.0	1(-6)	8(-6)	9(-6)
10.0 - 12.5	5(-5)	3(-6)	5(-5)
12.5 - 15.0	3(-5)	5(-6)	4(-5)
15.0 - 17.5	1(-5)	2(-6)	1(-5)
17.5 - 20.0	6(-6)	6(-6)	1(-5)
20.0 - 25.0	1(-5)	2(-6)	1(-5)
25.0 - 30.0	2(-5)	1(-6)	2(-5)
30.0 - 35.0	9(-7)	3(-6)	4(-6)
35.0 - 40.0	1(-6)	1(-6)	2(-6)
40.0 - 45.0	2(-8)	2(-6)	2(-6)
45.0 - 50.0	5(-8)	7(-7)	8(-7)
Total	8(-4)	2(-4)	9(-4)

*See Section 5.9.4.5(2).

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

***This circular zone includes the site exclusion area.

†7(-5) = 7 x 10^{-5} = 0.00007.

††93% of the area of this annulus is included within an annulus 1 mile wide outside 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

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CRITIQUE OF APPLICANT'S CONSEQUENCE ANALYSIS

In general, the applicant's analysis was comprehensive in scope and used methodology consistent with that used by the staff. Several significant differences in assumptions and input data between the applicant and the staff, however, are noted below. The applicant used 1980 population estimates while the staff used population data projected to the year 2010, which is about the plant's mid-life year. The staff has determined that the plant's mid-life year is more representative. The staff also disagreed with the 1980 population data used in the Millstone Probabilistic Safety Study (M-PSS) submitted by letter dated July 27, 1983 (the applicant later revised this).

The applicant used an assumed effective evacuation speed of 10 mph (4.47 m/sec) for internally initiated events, even though his contractor, Storch Engineers, calculated evacuation time estimates (Appendix 6-B of M-PSS) that are consistent with an effective evacuation speed of 2 mph. No evidence was given that assumptions based on the Storch results would lead to "unrealistic results [of consequence calculations]," as the applicant claimed. The staff assumed an evacuation speed of 2 mph and a delay time of 1 hour (the latter is consistent with that of the applicant). The special weighted evacuation scheme for M1 and M4 used by the applicant (Table 6.1-4) is more consistent with the staff's values. For seismically initiated events, the applicant assumed a delay time of 3.38 hours. The staff finds this unrealistic and overly optimistic. For instance, if siren towers were to fall because of an earthquake, mobile notification for evacuation (which the applicant postulates) would most probably also be difficult and/or ineffective. The staff assumed that for severe earthquakes, people would not relocate until 24 hours after the passage of the plume from an accidental release.

The applicant also presented source terms that are different from those used by the staff. In particular, the staff determined that the iodine releases specified by the applicant could be an order of magnitude too low. Other release values were comparable to those estimated by the staff.

Reference

Letter, July 27, 1983, from W. G. Counsil (Northeast Nuclear Energy Company) to B. J. Youngblood (NRC), Subject: Millstone Nuclear Power Station, Unit No. 3, Submittal of Probabilistic Safety Study.

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The information in this statement is the second assessment of the environmental impact associated with the construction and operation of the Millstone Nuclear Power Station, Unit No. 3, located in Waterford Township, New London County, Connecticut. The first assessment was the Final Environmental Statement related to construction issued in February 1974 prior to issuance of the Millstone Construction Permit. The present assessment is the result of the NRC staff review of the activities associated with the proposed operation of the plant.

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