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Report to the Nuclear Regulatory Commission from the Staff Panel on the Commission's Determination of an Extraordinary Nuclear Occurrence (ENO)

Office of the
Executive Director for Operations

U.S. Nuclear Regulatory
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APPROVALS OF STAFF PANEL ON THE
COMMISSION'S DETERMINATION OF AN
EXTRAORDINARY NUCLEAR OCCURRENCE

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December, 1979

I. INTRODUCTION

On August 17, 1979 the Nuclear Regulatory Commission directed that a panel composed of members of the principal staff should be formed to assemble information relevant to a determination of an extraordinary nuclear occurrence (ENO), evaluate public comments and report to the Commission its findings and recommendation. The Atomic Energy Act of 1954, as amended, defines the term "extraordinary nuclear occurrence" as "... any event causing a discharge or dispersal of source, special nuclear, or byproduct material from its intended place of confinement in amounts offsite, or causing radiation levels offsite, which the Commission determines to be substantial, and which the Commission determines has resulted or will probably result in substantial damages to persons offsite or property offsite." The Act further states that the "Commission shall establish criteria in writing setting forth the basis upon which the determination shall be made."

This panel was directed by the Commission to make explicit findings on whether the Commission's ENO criteria have been met, the factual basis for those findings, and a recommendation as to whether or not the accident at Three Mile Island constitutes an "extraordinary nuclear occurrence." The

Commission's regulations provide that the Commission will determine that there has been an extraordinary nuclear occurrence only if it determines that both criteria set forth in 10 CFR Part 140 of its regulations have been met.

II. FINDINGS AND RECOMMENDATION

As directed by the Commission on August 17, 1979, the Panel made its findings and recommendation by applying the explicit criteria set forth in the Commission's regulations, 10 CFR §§140.84 and 140.85, to the information gathered and analyzed by the Panel. The Panel has not addressed the question of whether the criteria set forth in 10 CFR §§140.84 and 140.85 for determining whether an ENO has occurred should be changed for future application. This matter will be considered in a separate rulemaking which the Commission has announced in response to the July 24, 1979 petition of the Public Citizen Litigation Group and the Critical Mass Energy Project. See 44 F.R. 50419, August 28, 1979.

The Panel finds that the first criterion, pertaining to whether the accident caused a discharge of radioactive material or levels of radiation offsite as defined in 10 CFR §140.84, has not been met. It further finds that there is presently insufficient information to support any definitive finding as to whether or not the second criterion, relating to damage to persons or property offsite as defined in 10 CFR §140.85, has been met. Since the Panel has not found that both criteria have been met, it recommends that the Commission determine that the accident at Three Mile Island did not constitute an "extraordinary nuclear occurrence."

III. BACKGROUND

In July, 1979 the Nuclear Regulatory Commission formally initiated, as described below, the making of a determination as to whether or not the accident at Three Mile Island Unit 2 (TMI-2) on March 28, 1979 constituted an extraordinary nuclear occurrence. Although the Commission at that time had not received a petition requesting such a determination (one was received shortly after the Commission published its notice inviting public comments on the determination), the Commission concluded that proceeding with the determination was in the public interest for two reasons. First, the Commission noted that the events at Three Mile Island constituted the most serious nuclear accident to date at a licensed U.S. facility, and thus should be rigorously scrutinized from the standpoint of its effect on the public. Second, the Commission noted the pendency of various lawsuits concerning the accident, in which the determination of whether or not an ENO had taken place was pertinent, and acknowledged the informal request of the Federal district court in Harrisburg that the Commission make this determination as expeditiously as possible.

On July 23, 1979, the Commission published a notice in the FEDERAL REGISTER inviting interested parties to submit to the Commission within thirty days any information in their possession relevant to the determination. The Commission also established this Panel to consider the information provided by the comments along with information independently assembled by the Panel.

IV. RELATIONSHIP OF ENO DETERMINATION TO RECOVERY FOR NUCLEAR INJURIES OR DAMAGES

In the event of a nuclear accident (or nuclear "incident" as the term is used in the Atomic Energy Act), claims for injuries or damages can be brought against the plant licensee and other parties considered responsible for the accident. The Price-Anderson provisions of the Atomic Energy Act (Section 170) provide a system of private insurance, electric utility funds, and government indemnity totalling $560 million to pay such public liability claims. One of the principal obstacles to a claimant's recovery for injuries or damages could be the necessity of proving negligence on the part of the defendants. Congress attempted to remove this obstacle in 1966 by amending the Price-Anderson Act to introduce the closely related concepts of extraordinary nuclear occurrence and waiver of defenses. When the Commission determines that a nuclear incident was an "extraordinary nuclear ocurrence" within the meaning of the Act and the Commission's regulations, then the waiver of defenses provisions of the insurance policies and indemnity agreements making up the Price-Anderson system are activated, resulting in an essentially "no-fault" recovery scheme. When the Commission has determined that an ENO has occurred, any defendant must waive:

(i) Any issue or defense as to the conduct of the claimant or fault of persons indemnified,

(ii) any issue or defense, as to charitable or governmental immunity, and

(iii) any issue or defense based on any statute of limitations if suit is instituted within three years from the date on which the claimant first knew, or reasonably could have known, of his injury or damage and the cause thereof, but in no event more than twenty years after the date of the nuclear incident.

Unless an ENO is declared by the Commission, the waiver of defenses provisions do not apply. Whether or not an ENO is declared, however, a claimant would still have to prove that he was injured or damaged, the monetary amount of his loss, and the causal link between his loss and the radioactive, toxic, explosive or other hazardous properties of the radioactive material released. When applicable, the waivers of defenses provisions relieve the claimant of having to prove negligence by any defendant and of having to disprove defenses such as contributory negligence.*

V. FORMATION OF THE ENO PANEL

On August 24, 1979, in response to the Commission's direction, a panel composed of members of the principal staff and chaired by the Executive Director for Operations was formed. The Panel created a working group drawn from the staffs of various NRC offices to assist in the review of public comments, data analysis and evaluation, and the drafting of the Panel's

* More detailed information on the concepts of extraordinary nuclear occurrence and waivers of defenses can be found in the "Background Information" attached to the NRC's news release of July 20, 1979 (No. 79-121) entitled "NRC Invites Public to Submit Information to Assist in Determination of Three Mile Island Accident," included as Appendix B.

findings and recommendation to the Commission. The members and alternates of the Panel and members of the working group are listed in Appendix A.

An important responsibility of the Panel was to review and analyze the public comments received. Some 57 written comments were received by mid-December. One of the comments requested that the Commission hold a public hearing in the Harrisburg area to receive statements from members of the public. In response to this request, and in the interest of compiling as complete a record as possible for making the ENO determination, selected Panel members and supporting staff held a one-day informal hearing on November 21 in Harrisburg. (See Appendix B for a copy of the Federal Register Notice and public announcement of the hearing.) Seven individuals made oral statements and additional written statements were provided for the record. A transcript of the hearing was made and reviewed by the Panel. This transcript, which forms a part of the record of the Panel's deliberation, has been placed in the Commission's public document room and the local TMI public document room.

While only a few of the public comments have provided data applicable to the specific criteria in the regulations governing the ENO determination, all of the comments have been carefully considered, and a Panel response has been prepared for each category of comment. (A summary of the comments received and the Panel's responses are included in Appendix C.) In those cases where specific data were provided, more extensive Panel responses are included.

In some cases, working group members followed up directly with commenters to obtain background information which could support statements made in the comments. Commenters at the hearing were urged to provide in writing data referred to in their oral statements.

VI. WORK BY OTHERS

The Panel and its working group reviewed release data and potential health impact information from the TMI accident derived from studies by NRC staff and parties outside of NRC. This included important recalculations carried out on behalf of the President's Commission on the Accident at Three Mile Island (Kemeny Commission).* The Environmental Protection Agency (EPA) was given the responsibility by the White House staff for compiling environmental data from all Federal agencies, the licensee, the states of Pennsylvania, New Jersey, and New York, local hospitals, and a number of private concerns. The purpose of this compilation of data by EPA was to provide a focal point for all monitoring data collected and to determine whether a reassessment of projected dose was called for as a result of the review of the raw data. All of the collected data was put in a common format, returned to the originating agencies and organizations for verification, and sent to the Presidential

* The Panel notes that the Report of the President's Commission and the supporting Task Group reports (see Appendix D, Items e, f, and g) are consistent with the findings made in this report with respect to radiological impacts.

Commission on the Accident at Three Mile Island for its use. The Panel received a briefing from EPA officials responsible for the data collection and review and has been kept apprised of the continuing work being carried out by EPA with respect to the possible reassessment of the data.

EPA convened an interagency committee in November, 1979 to determine whether there was need of further reassessment of the doses from the accident. The interagency commiteee found that there were no additional data that would substantially alter previous dose estimates. Therefore, further reanalysis would not significantly change the conclusions already reached (see Appendix B). A list of dose assessment and environmental monitoring data collection studies considered by the Panel in the course of its review are included in Appendix D.

VII. LANGUAGE AND STRUCTURE OF THE CRITERIA FOR DETERMINING AN ENO

For the Commission to determine that there has been an ENO, both Criterion I and Criterion II as set out in the Commission's regulations (10 CFR §§140.84 and 140.85) must be met. The language of the criteria (especially Criterion I) is rather technical and precise. Criterion I relates to whether there has been a substantial discharge or dispersal of radioactive material off the site of the reactor, or that there has been a substantial level of radiation offsite. Criterion I calls for such a finding when, radioactive material is released from its intended place of confinement or radiation levels occur offsite and either of the following findings are also made:

a. That one or more persons offsite were, could have been, or might be exposed to radiation or to radioactive material, resulting in a dose or in a projected dose in excess of one of the levels in the following table:

TABLE I - TOTAL PROJECTED RADIATION DOSES

Critical Organ	Dose (rems)
Thyroid	30
Whole body	20
Bone Marrow	20
Skin	60
Other organs or tissues	30

In measuring or projecting doses, exposures from the following types of radiation shall be included.

(1) Radiation from sources external to the body;

(2) Radioactive material that may be taken into the body from air or water; and

(3) Radioactive material that may be taken into the body from food or from land surfaces.

<u>or</u>

b. (1) As the result of a release of radioactive material from a reactor there is at least a total of any 100 square meters of offsite property that has surface contamination. This contamination must show levels of radiation in excess of one of the values listed in column 1 or column 2 of the following table, <u>or</u>

(2) As the result of a release of radioactive material in the course of transportation surface contamination of any offsite property has occurred. The contamination must show levels of radiation in excess of the values listed in column 2 of the following table.

TABLE II. TOTAL SURFACE CONTAMINATION LEVELS*

Type of emitter	Column 1 Utility's property beyond the fence surrounding the reactor station.	Column 2 Other offsite property
Alpha emission from transuranic isotopes	3.5 microcuries per square meter	0.35 microcuries per square meter
Alpha emission from isotopes other that trans-uranic isotopes	35 microcuries per square meter	3.5 microcuries per square meter
Beta or gamma emission	40 millirads/hour at 1 cm. (measured through not more than 7 milligrams per square centimeter of total absorber)	4 millirads/hour at 1 cm. (measured through not more than 7 milligrams per square total absorber)

* The maximum levels (above background), observed or projected, 8 or more hours after initial deposition.

If Criterion I is satisfied, Crierion II must then be applied. Criterion II is satisfied if any of the following findings is made:

(1) The event has resulted in the death or hospitalization, within 30 days of the event, or five or more people located offsite showing objective clinical evidence of physical injury from exposure to the radioactive, toxic, explosive or other hazardous properties of the reactor's source, special nuclear, or byproduct material; or

(2) $2,500,000 or more of damage offsite has been or will probably be sustained by any one person, or $5 million or more of such damage in total has been or will probably be sustained, as the result of such event; or

(3) The Commission finds that $5,000 or more of damage offsite has been or will probably be sustained by each of 50 or more persons, provided that $1 million or more of such damage in total has been or will probably be sustained, as the result of such event.

The term "damage" refers to damage arising out of or resulting from the radioactive, toxic, explosive, or other hazardous properties of the reactor's source, special nuclear, or byproduct material, and shall be based upon estimates of one or more of the following:

(1) Total cost necessary to put affected property back into use,
(2) Loss of use of affected property,
(3) Value of affected property where not practical to restore to use,
(4) Financial loss resulting from protective actions such as evacuation appropriate to reduce or avoid exposure to radiation or to radioactive materials.

VIII. Criterion I - Substantial Discharge or Dispersal of Radioactive Material Offsite or Substantial Levels of Radiation Offsite

The Panel approached the question of whether there was a substantial discharge or dispersal offsite of radioactive material or substantial levels of radiation offsite by attempting to determine, through examining the radiation levels detected offsite, the measured releases from the site and the local time-dependent meteorology, whether any of the levels delineated in Criterion I were met or exceeded.

A. Assumptions

1. Duration of the Accident

The Panel made certain assumptions in making its findings. First, it postulated that for the purpose of the ENO determination, the accident lasted from March 28, 1979 to May 9, 1979. The latter date is the one that the Panel considers to be the time, after the reactor was placed in a configuration for natural cooling, when all discharges from the reactor were within the dose levels and concentrations specified in Appendix I to 10 CFR Part 50 ("Numerical Guides for Design Objectives and Limiting Conditions for Operations to Meet the Criterion 'As Low as is Reasonably Achievable' for Radioactive Material In Light-Water-Cooled Nuclear Power Reactor Effluents") and 10 CFR Part 20 ("Standards for Protection Against Radiation") of the Commission's regulations. This forty-three day period incorporates all of the iodine releases and virtually all of the noble gas releases. While further small releases were made from the TMI-2 reactor after that time, and indeed continue to be made, these releases are all within the allowable releases for normal operation specified in the Commission's regulations and the TMI-2 license. More importantly, releases after that period would add less than 1% to the doses described in the Appendices to this report. The Panel believes that further significant releases would be likely to occur only if a separate accident sequence -- such as a transportation incident -- was initiated, and that any such event would be a separate "nuclear incident" within the meaning of the Price-Anderson Act.

The Panel wishes to emphasize that in postulating a limited duration for the Three Mile Island accident, the Panel is doing so for ENO purposes only. It recognizes that in other contexts one could conclude, as did the President's Commission, that the accident is continuing.

The Commission has determined that important public interest considerations favor a timely ENO determination with respect to the events which have already occurred. The Panel believes that since it may be years before the reactor is decontaminated, and the possibility of additional releases thus ended, delay is unnecessary and the conclusion for ENO purposes that the accident has ended is justified on technical and public interest grounds.

2. Meaning of the Term "Offsite"

The Panel considered a number of alternatives for determining the meaning of the term "offsite" as used in the criteria. The indemnity location described in Indemnity Agreement B-64 between Metropolitan Edison Company et al. and the Commission is as follows:

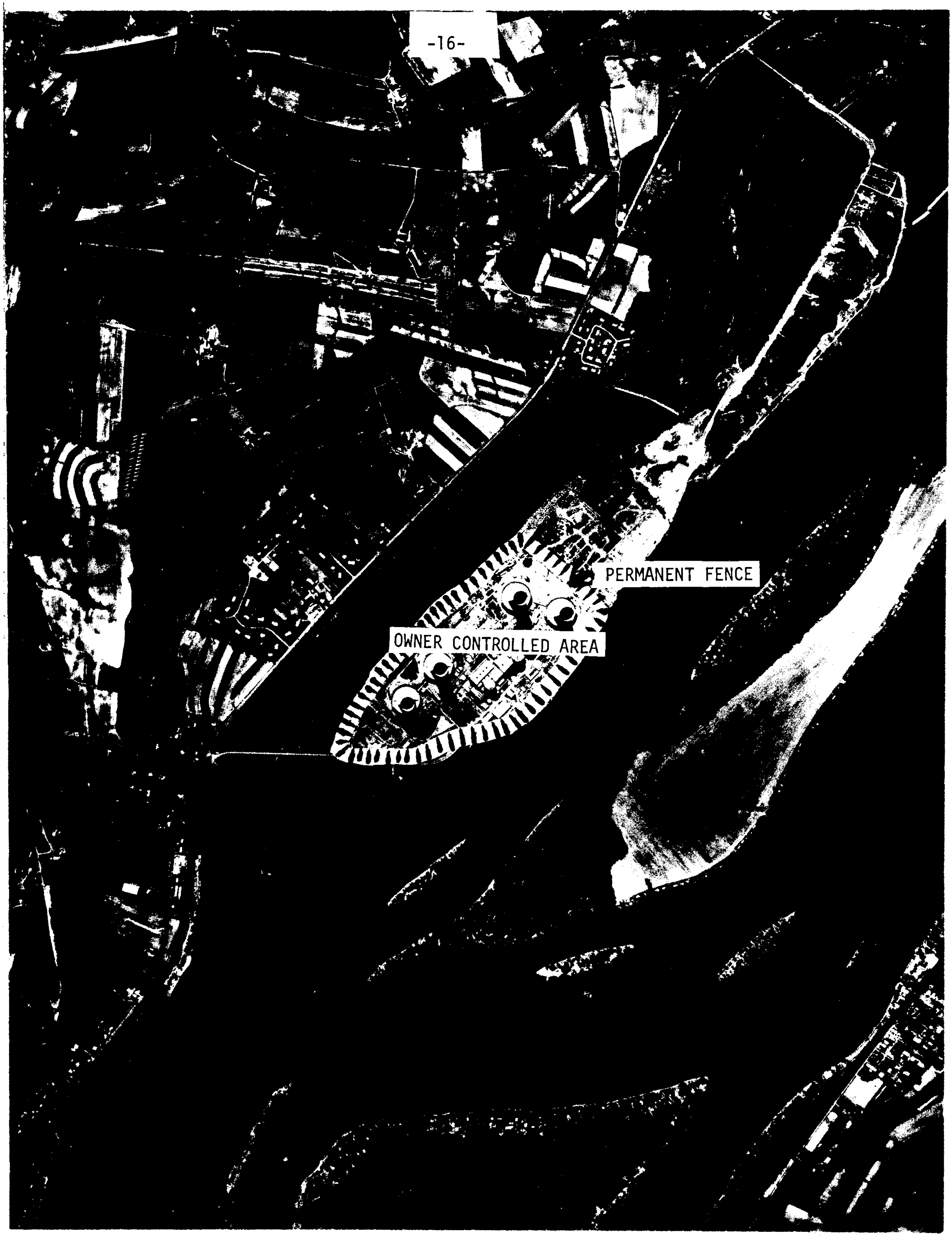
> All of the premises including the land and all buildings and structures known as the Three Mile Island Nuclear Station including but not limited to Units 1 and 2. The Three Mile Island Nuclear Station is located on Three Mile Island near the east shore of the Susquehanna River above York Haven Dam. The site is located approximately ten (10) miles southeast of the City of Harrisburg in Londonderry Township, Dauphin County, Pennsylvania.

The site, owned directly by Metropolitan Edison, is located on the north portion of Three Mile island. The remainder of Three Mile Island is owned by a wholly-owned subsidiary of Metropolitan Edison (York Haven Power Company). The Three Mile Island buildings and structures exist in what is called the "owner controlled area." This owner controlled area is surrounded by a permanent fence. (See map on Page 16) The Three Mile Island Nuclear Station might be defined as including only the buildings, structures, and land within the permanent fence, or, more broadly, include the remaining land area also owned by Metropolitan Edison but outside the fence.

If the area only within the permanent fence is considered to be the nuclear station, then this enclosed area would be the defined on-site location. The closest offsite measurement point would be just outside the permanent fence. If, on the other hand, the remaining utility owned area outside the permanent fence is considered to be the nuclear station, then the closest offsite point is at a location in the river adjoining the island. For all practical purposes, however, it makes little difference in terms of measurement data which definition of "offsite" is chosen, since a distance of less than 100 feet separates the nearest offsite points in the two cases. The Panel has concluded that the most conservative definition of "offsite" would include all areas, whether or not owned by the licensee, outside of the owner-controlled area enclosed by the permanent fence on Three Mile Island. In cases where a specific site definition was necessary, the Panel used this site.

3. Characterization of the Offsite Persons Exposed

The criteria are somewhat ambiguous with respect to the characterization of the offsite persons whose exposure to radiation must be measured. Section 140.84(a) of the regulations speak in terms of "one or more persons offsite [who] were, could have been, or might be exposed..." (emphasis added). This phraseology is not found in the Price-Anderson Act. The statement of considerations that accompanied the promulgation of the criteria in 1968 does not clearly describe the identification of a person offsite who "could


PERMANENT FENCE
OWNER CONTROLLED AREA

have been" exposed to radioactive material or radiation. One possibility would be a real person, in the path of possible exposure but for whom direct measurements of exposure were not taken. A second would be a real person who, but for being evacuated from a particular place, would have been exposed to radiation. A third possibility would be a hypothetical person placed on a spot where the highest levels of exposures would be expected to have taken place. This could be in either a place easily accessible to the public or in a less accessible spot (for example, in the river just beyond the site boundary). Finally one could visualize a hypothetical person given the mobility and knowledge to continually travel so as to be located wherever the highest levels of exposures existed at any given time.

The Panel chose to evaluate whether Criterion I was met in terms of various possible versions of people who "could have been" exposed. Under one assumption, individuals were assumed to be located at points corresponding to the highest recorded doses where, in fact, no individuals are known to have been. Also a statistical measurement error was added to the dose readings at these locations corresponding to one chance in a thousand (99.9th percentile) of being exceeded. No allowance was made in these calculations for the demonstrated over-response of the thermoluminescent dosimeters to the radiation emitted during the accident. This over-response indicates that the measured values may have exceeded the actual doses by a factor between 1.2 and 2.2. The Panel also considered a hypothetical person exposed outdoors for the periods of releases of noble gas and iodine from the accident and placed just offsite at spots that the Panel concluded would have seen the highest exposure. Finally, in order to obtain an upper limit for possible exposure to compare against the values in Criterion I, a person was hypothesized to have the ability and knowledge to be transported so as to always be in the area of highest radiation exposure during the course of the accident.

B. Approach of the Technical Studies

The two technical studies (Appendices E and F) appended to the Panel's report approach the question of estimating doses to persons from two different and independent directions. In Appendix E, radionuclides released to the atmosphere are determined: (a) from the Department of Energy helicopter measurements of the noble gases in the plume and; (b) for iodine, by continuous sampling of the Unit 2 vent effluent streams. The report then estimates doses that would be possible to people based on the radioactive material released, the meteorological conditions transporting and depositing these releases, and on hypothesized individuals' locations and stay times, chosen to maximize possible dose. Appendix E also presents calculations for offsite ground contamination levels and shows that neither the 10 CFR §140.84 dose criteria nor ground contamination criteria were exceeded. The Appendix F report reconsiders the noble gas doses based on actual measurements with offsite thermoluminescent dosimeters (TLD) already in place at specific onsite and offsite locations when the accident occurred. This report also discusses measured surface contamination levels and their relationship to the values in 10 CFR §140.84(b).

C. Summary of Technical Report on Gaseous Releases and Releases in Water in Terms of Dose to People and Contamination of Property (Appendix E)

In Appendix E, calculations of doses to individuals are made for releases of iodine 131 and noble gases to the atmosphere. Calculations are also made for ground contamination and for releases to the aquatic environment. In making estimates of doses due to the iodine and noble gas releases to the atmosphere, several hypothetical situations were assumed. These calculations placed individuals at locations near the plant where the dose would be highest and for a period of time extending throughout the duration of the releases. The results of all of these calculations indicated doses below the levels of 10 CFR 140.84 for all hypothetical cases. In several of the calculations that were made, assumptions were employed to ensure that the results represented upper bound estimates. These assumptions are as follows: (1) the use of a source term that was greater than the best estimate of releases that actually occurred, (2) no credit taken for any additional decay of radionuclides over time after release from the facility, and (3) meteorological models based on assumptions that tend to underestimate actual dispersion (described in Appendix E). The calculations regarding releases to the aquatic environment resulted in very small estimates of dose, as expected, since the releases were within the technical specification requirements of the Metropolitan Edison license for normal operation. Thus, the liquid radionuclide pathways resulted in doses which were a small fraction of the levels stated in 10 CFR 140.84. Several estimates of ground contamination were made for locations off the Three Mile Island site using the same hypothetical assumptions as used in the dose calcuations. The ground contamination values were also below the levels of 10 CFR 140.84.

Calculations of doses due to the noble gas releases (principally xenon) for hypothetical and real individuals offsite who received the highest exposure have been made by several different groups. The results of three of these groups are presented in Appendix E with a brief description of their methods. All studies consistently conclude that the maximum offsite dose at the likely location of a real person is less than 100 mrem. Nevertheless, the possibility was examined that an offsite individual may have been closer to the plant than was determined in the analyses mentioned above. A hypothetical situation was constructed whereby an individual was assumed to be located in a boat along the perimeter of the island for the entire course of the releases of noble gases. Furthermore, in order to establish the maximum dose such a hypothetical individual could receive, it was assumed that the individual moved the boat as the wind shifted so that it was always downwind of the plant in the radioactive plume. This scenario resulted in a dose of 2.3 rem total body and 4.7 rem skin. Both of these dose values are well under the Criterion I levels of 20 rem whole body and 60 rem skin.

Estimates of inhalation dose from iodine-131 for the nearby populated area were based on the forty-three day period which incorporated all of the iodine releases. The calculated dose was 19 mrem to the thyroid of a child. This calculation was for locations offsite where individuals would be expected to be located and the dose was expected to be highest. To take into consideration the possibility that an individual might have been located closer to the plant, calculations were done for several hypothetical individuals. One calculation was based on the assumption that the individual was located at one spot just offsite in the sector where the dose would be highest for the entire forty-three days (24 hours per day) of the releases. This was intended to apply to a hypothetical individual who could have been near Three Mile Island. The calculated dose was 3.9 rem to the thyroid of a child. Another calculation was made for an individual at one spot on the nearest shoreline to which the general public had access. The calculated dose was 1.4 rem to the thyroid of a child. Again, it was assumed that the hypothetical individual was there for the entire forty-three day release period and was located where the dose would be expected to the highest. Finally, another calculation, similar to the noble gas calculations noted above, was based on the assumption that a hypothetical individual was located just offsite for the entire forty-three day period and moved around it in such a way to be located always downwind of the plant. The calculated dose was 17.5 rem to the thyroid of an adult.* Upper bound values of the

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* These calculated doses represent the results for the age class and organ which would have received the maximum dose. The results of calculations of other age groups and organs can be found in Appendix E.

The scenario of an individual moving around to stay in the plume is somewhat more realistic for noble gas releases because the duration of the noble gas releases was short (most over a three day period) and the dispersion occurred in three predominant directions. Hence, if an individual was in a boat for several days in the direction where doses would be expected to be highest, the estimate developed by this scenario would be larger but representative of the actual dose the individual would have received. In the case of the iodine releases which lasted 43 days, there was no predominant direction in which most of the material was dispersed in comparison to the noble gas releases; hence, for a person to receive this dose would require knowledge of the plume location and a desire to stay in it. In the judgment of the Panel this scenario is completely unrealistic.

source term and the meteorological dispersion parameters that were previously mentioned were used in these hypothetical calculations. The dose results of all of these approaches were below the level of 10 CFR 140.84.

In summary,dose calculations based on gaseous releases and releases in water support a finding that the criteria for substantial offsite doses or substantial releases of radioactive materials were not met as a result of the accident on March 28, 1979 at Three Mile Island Nuclear Station, Unit 2.

D. Technical Report on Review Environmental Measurements

The results of radiation doses measured by TLD's located in the vicinity of the site indicate that the highest whole body radiation dose to a possible real individual was less than 0.1 rem to individuals located at the nearby residences on the east bank of the river. The maximum whole body dose that could have been received by a hypothetical individual was estimated to be approximately 1.4 rem for an individual located on the north northwest corner of Three Mile Island and less than 1.2 rem for an individual located on Kohr Island. In all three cases, no allowance has been made for reductions in actual radiation doses due to actual occupancy time (full time occupancy from 4 A.M. on March 28, 1979 to April 15, 1979 was assumed*), the demonstrated overresponse of the TLD's (which leads to measured values between 1.2 and 2.2 times greater than the acutal doses) or for shielding due to being

* Results of longer term measurements made by NRC, FDA, and the licensee show that noble gas whole body dose contributions after April 6, 1979 are negligible.

indoors. The "could have been" hypothetical estimates include allowance for statistical measurement errors so that the probabilty of the stated value being exceeded is one chance in a thousand (99.9th percentile). More likely estimates of these hypothetical doses, incorporating the energy overresponse corrections, would be less than 1 rem at both locations. Therefore, it is likely that the dose any individual could have received would be at least a factor of 10 lower than the Part 140 criterion of a 20-rem whole body dose.

An individual who was on Hill Island could have received a dose of approximately 0.3 rem if he had remained continuously at this location throughout the period from 4:00 A.M. on March 28th until March 31st. However, actual occupancy times for this man indicate that he departed before the persistent winds began blowing into the NW-NNW sectors on the night of March 28th, when the majority of the dose at this location would have been delivered. The actual dose received is estimated to be less than 0.05 rem (50 millirem).

Surface contamination levels were assessed by a variety of measurement techniques, with most of the results orders of magnitude below the levels in the criteria. Except for one location on Three Mile Island, the only deposited radionuclide which was detected in concentrations greater than those measured in 1977 was iodine-131. The highest radioiodine concentration would have resulted in a dose rate of less than 0.2% of the criterion of 4 millirads per hour (a factor of 600 less than the criterion).

Cesium-137 and cerium-144 (and naturally occurring radionuclides) were also found in most soil samples, but at levels consistent with pre-accident levels as determined by 1977 soil analysis results. These radionuclides, in offsite samples, would have resulted in dose rates less than 0.02% of the criterion of 4 millirad per hour.

One soil sample collected on Three Mile Island had levels of cesium 137, cesium-134, and cobalt-60 higher than those found elsewhere. This location had been reportedly used for low activity contaminated waste; hence these levels were most likely caused by residual contamination rather than the accident. The combined dose rate from cesium-137, cesium-134, cobalt-60 and radioiodine-131 (found in an adjacent sample) would be 1.4 percent of the 4 millirem per hour (0.06 mR/hr) criterion. However, as this measurement was on licensee controlled land contiguous to the site, the 40 millirad per hour dose rate criterion would be applicable to this location. The estimated dose rate would be approximatly 0.15 percent of (or a factor of 600 lower than) the 40 millirem/hour criterion.

In summary, environmental measurements support a finding that the criteria for substantial offsite doses or substantial releases of radioactive materials were not met as a result of the accident on March 28, 1979 at the Three Mile Island Nuclear Station, Unit 2.

IX. CRITERION II - SUBSTANTIAL DAMAGE TO PERSONS OFFSITE OR PROPERTY OFFSITE

10 CFR §140.85 of the Commission's regulations provides that, when the Commission has determined that an event has satisfied Criterion I, the Commission will determine whether Criterion II has been met, i.e., whether the event has resulted or will probably result in substantial damages to persons offsite or property offsite as would be shown by any one of three specified findings. As in the case of Criterion I, the measures of whether Criterion II is met are precisely delineated. Section 140.85 clearly specifies that Criterion II will not be applied until after the Commission has determined that an event has satisfied Criterion I.* Despite the finding made by the Panel that Criterion I has not been satisfied, we believe that the Commission and the public (which will have the opportunity

* The discussion of the ENO criteria in subsection 140.81(2) states that the "only interrelation between the values selected for the discharge criteria and the damage criteria is that the discharge values are set up low so that it is extremely unlikely the damage criteria could be satisfied unless the discharge values have been exceeded." As described earlier, the Panel has concluded that the discharge values in Criterion I were neither met nor exceeded and accordingly recommends that the Commission determine that there had been no ENO. Contrary to the predicted interrelationship between the criteria, under some interpretations of the elements of "damage," the damage criterion might be satisfied even though the discharge criterion was not. This would still not lead to a finding of an ENO since both criteria must be satisfied.

to comment on the Panel report before the Commission makes the ENO determination) should have the Panel's thoughts on the evidence as to whether Criterion II has been satisfied. Indicative of the public interest in Criterion II is the emphasis placed on damages in the comments responding to the Commission's July 23 notice and in the hearing held in Harrisburg on November 21.

As described below, the Panel believes that it is not clear from the evidence available to date whether the second criterion has been met.

Required Findings

> "... (1) The Commission finds that such event has resulted in the death or hospitalization, within 30 days of the event, of five or more people located offsite showing objective clinical evidence of physical injury from exposure to the radioactive, toxic, explosive, or other hazardous properties of source, special nuclear, or byproduct material;"

The Panel is not aware of the death or hospitalization of any person located offsite showing objective clinical evidence of physical injury from exposure to the hazardous properties of the nuclear material from TMI-2. The Panel checked specifically with the Bureau of Radiation Protection in the Pennsylvania

Department of Environmental Resources to assure itself that the Bureau was not aware of any such cases that would have otherwise escaped public notice.*

The Panel recognizes that there were emotional and psychological impacts of the accident that could have been manifested in many ways, including physical symptoms similar to those that could be associated with exposure to radiation. Such effects, however, unless evidencing physical injury from the hazardous properties of the radioactive material, are not considered in the provisions of the criterion.

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* A comment received (from Three Mile Island Alert, Inc.) mentions one severe allergic reaction to iodine and at least two psychological breakdowns that resulted in hospitalization within one month of the accident. Also mentioned was the hospitalization for the recurrence of psychosis of another patient. Some deaths and hospitalization for the residents of a nursing home who were evacuated because of a lack of staff were also mentioned. Another comment (from the Environment Coalition on Nuclear Power) mentions the "experiences of the many individuals within a 20-mile radius of TMI-2 who observed symptoms of radiation sickness ... such as sore throat, nausea, diarrhea, skin disorders, burning eyes, fatigue, etc." At the hearing held by the Panel in Harrisburg on November 21 to receive additional comments, views were expressed that these types of symptoms as well as others were experienced by a number of residents of the area but because of the press of other considerations at the time following the accident, most individuals experiencing these symptoms did not attempt to receive professional medical attention. Finally, a view was expressed that such occurrences as stillbirths in the area surrounding TMI and anywhere where residents from that area might have gone and respiratory deaths from elderly residents in TMI area should also be considered by the Panel considering this provision of Criterion II. The Panel does not believe that any of these instances constitute hospitalization of persons showing objective clinical evidence of physical injury from exposure to the hazardous properties of nuclear material. Further inquiry was made to obtain substantiation of the allergic reaction to iodine instance mentioned but to date the informal information conveyed has remained ambiguous. The Pennsylvania Bureau of Radiation Protection had no information with respect to these instances of possible injury.

Some commenters indicated that it is too early for cancers or other manifestations of the effects of exposure to the hazardous properties of nuclear material to be detected. The Panel notes that Criterion II speaks of death and hospitalization within thirty days of the event. Clearly, this criterion was intended to be triggered by acute physical injuries rather than radiation exposures which might result in future cases of cancer. As indicated earlier in this report, the Panel believes that a reasonable measure of the duration of the TMI-2 accident for the purposes of the ENO determination is from March 28, 1979 to May 9, 1979, which encompasses the period from the start of the accident to that time, after the reactor was placed in a configuration for natural cooling, when all discharges from the reactor were within the dose levels and concentrations specified in Appendix I of 10 CFR Part 50 (Criterion for "As Low as is Reasonably Achievable") and 10 CFR Part 20 ("Standards for Protection Against Radiation") of the Commission's regulations. This period incorporates all of the iodine releases and virtually all of the noble gas releases. Using this definition of the accident's duration, the Panel has not found that there were any deaths or hospitalization within thirty days of the accident of five or more people located offsite showing objective clinical evidence of physical injury from exposure to the hazardous properties of the radioactive material from TMI-2.

> "... (2) The Commission finds that $2,500,000 or more of damage offsite has been or will probably be sustained by any one person, or $5 million or more of such damage in the aggregate has been or will probably be sustained, as the result of such event; or

> (3) the Commission finds that $5,000 or more of damage offsite has been or will probably be sustained by each of 50 or more persons, provided that $1 million or more of such damage in the aggregate has been or will probably be sustained as the result of such event."

The Panel is aware of the large number of lawsuits and other claims that have been filed as a result of the TMI-2 accident with allegations of damage totalling hundreds of millions of dollars. In light of the large number and nature of claims, the Panel could speculate that the specified dollar level of damage "in the aggregate has been or will probably be sustained as the result of such event." To its knowledge these claims do not allege damage in the nature of a physical abuse to the property (such as might come from contamination) that can be easily measured. Rather, the damages claimed relate to expenses (such as temporary living expenses) incurred by members of the public as a result of the accident, or to alleged declines in the value of the property. At this point, the Panel is unable to place a monetary level on such damage. It may be that the dollar figure for payments of such claims could reasonably act as a surrogate or substitute for the figure of "offsite damage," or at least that the detailed accounting necessary to support such claims could satisfy the criterion. Even if this were so -- and the Panel is not convinced that such claims do indeed represent "offsite damage" for ENO purposes -- either a figure on payable claims set by the courts or a compilation of the financial data supportive of such claims will probably not be produced for sometime. The most recent figure of $1,306,495 representing (as of December 14,1979) the claims paid by the two nuclear insurance pools for evacuation and related expenses give little indication of what outstanding claims might be sustained by the courts.

One difficulty in using claims paid, whether voluntarily by the insurance pools or under the direction of courts, is that the various lawsuits and claims may combine a number of types of injuries and damages, some of which might not necessarily fall within the categories of damage enumerated in 10 CFR §140.85(b). In this regard, the regulation states that:

> "... As used in subparagraphs (2) and (3) of paragraph (a) of this section, "damage " shall be that arising out of or resulting from the radioactive, toxic, explosive, or other hazardous properties of source, special nuclear, or byproduct material, and shall be based upon estimates of one or more of the following.
>
> (1) Total cost necessary to put affected property back into use,
>
> (2) Loss of use of affected property,
>
> (3) Value of affected property where not practical to restore to use,
>
> (4) Financial loss resulting from protective actions appropriate to reduce or avoid exposure to radiation or to radioactive materials."

As stated above, the Panel is not aware of any property having been removed from use because of any physical injury to that property through contamination by radioactive material or other means. No decontamination of any kind had to be carried out with respect to offsite property and no restoration work needed to be undertaken. The loss of use that is typically claimed is related to such matters as the closing of a business due to evacuation by the proprietor or employees or, if the enterprise remained open, a loss of sales or business. One comment received in response to our Federal Register Notice, for example, stated that "As a consequence of the release of radioactive material and radiation from Three Mile Island, many businesses experienced a reduction in sales of their goods or reduced demands for their services. Based upon statements of my own personal clients, I would estimate that the damages sustained easily meet the minimum requirements for an ENO finding." Particular emphasis was placed by one witness at the hearing held by the Panel in Harrisburg on November 21, on the loss of tourism in Pennsylvania and the Pennsylvania Dutch Country in the TMI region as representing an acute loss of value of property.

Two of the measures of damage to property ("total cost necessary to put affected property back into use" and "value of affected property where not practical to restore to use") strongly imply some sort of physical abuse of the property, such as contamination that either requires a cost to restore the property to use (e.g., a cost of decontamination) or causes a total loss of the property because it cannot be practically restored to use. In the context of these two categories of damage, the "loss of use of affected property" could reasonably be read as the loss of use of the property during the period after the accident and before the property was restored to use or its value replaced. With such a reading, the loss of use of property where no physical abuse of the property has taken place could be considered not to be "damage" for the specific purpose of making an ENO determination. The Panel is not convinced, however, that for all its apparent logic, such a reading of "loss of use of affected property" is inevitable. An equally acceptable interpretation of the phrase "loss of use of affected property" would include property voluntarily removed from service due to a fear of possible contamination even though the property was never actually contaminated nor indeed even in danger of being contaminated. The phrase might also include property or the value of property shunned by others because a psychological association with the TMI accident. The Panel finds that there is simply no data available at the present time quantifying the damage incurred under this expansive reading of "loss of use of affected property."

Specific Amounts of Damage

In addition to specificity as to the type of "offsite damage" that must be met, there is also the specificity of the calculation of damage amounts that must be considered, namely:

> $2,500,000 or more of damage has been or probably will be sustained by any one person or $5,000,000 or more in the aggregate.
>
> or
>
> $5,000 or more of damage by each of 50 or more persons provided that $1,000,000 or more of such damage has been or will probably be sustained.

As speculative as is the question of whether the Three Mile Island accident reached the prescribed aggregate levels of damages (i.e., the $1 million and $5 million figures) that might "ha[ve] been or probably will be" sustained as a result of "loss of use of affected property," it is even more speculative as to whether such damage as may have been or may be sustained from this accident can meet the very specific "unit" criteria in the regulation (e.g., $2,500,000 by any one person; $5,000 or more by each of 50 persons).* The largest single claim related to the loss of use of property of which the Panel is aware (from information provided by the nuclear insurance pools) is for a total economic loss by one company on the order of $685,000. Other claims allege damages in the range from $150 to $100,000, with an average (excluding the one claim mentioned in the previous sentence) of about $14,000. It should be noted, however, that of the 116 economic consequence claims received by the pools as of December 14, 1979, only 60 have included an actual dollar amount for damages.

The final category with respect to the estimate of damage is the financial loss resulting from protective actions appropriate to reduce or avoid exposure to radiation or to radioactive materials. The most obvious example of protective actions would be evacuation of persons or livestock. Tens of

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* The Panel recognizes that if the $5 million level in aggregate damages is reached it is unnecessary to calculate whether any of the "unit" criteria were met.

thousands of people within the five-mile radius of the TMI-2 reactor covered by the Governor's evacuation advisory, as well as others outside of the five-mile radius, evacuated the area after the March 28 accident. It is far from clear at this time whether all or just some of the evacuations would be considered "appropriate" actions to reduce or avoid exposure to the radiation or radioactive material from the TMI-2 accident.

As described earlier, however, regardless of which of the evacuations might be considered to have led to "financial loss resulting from protective actions appropriate to reduce or avoid exposure" to the radioactive material from the TMI-2 accident, the damages borne by the evacuees would have to reach the levels (that is, 50 or more persons sustaining $5,000 each) prescribed in the regulations (unless the aggregate damages were $5 million). Using the per diem rates utilized by the nuclear insurance pools to reimburse parties who evacuated pursuant to Governor Thornburgh's advisory (namely $50 per person per day) each of 50 such persons would have had to receive such per diem for 100 days. This did not occur.*

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* A report prepared under contract to the NRC by Mountain West Research Inc. with Social Impact Research Inc. provides another perspective on this question. The preliminary report on the "Three Mile Island Telephone Survey" (NUREG/CR-1093) September, 1979 concludes that based on survey information provided by telephone contacts of a large sample of households in the TMI area, the total cost of the accident to households within 15 miles of TMI was estimated at $18 million of which evacuation costs represented some $8.8 million. The median cost of evacuation was given as $100 per household. The median length of stay outside the area was 5 days, and the range was from 1 to 62 days.

In summary, the Panel finds that Criterion II presents several difficult problems of interpretation, the resolution of which would effect the determination of whether the criterion had been satisfied. In any event, the evidence available at this time is insufficient for the Panel to determine whether Criterion II has been satisfied.

APPENDIX A

Membership of Staff Panel on the Commission's Determination of an Extraordinary Nuclear Occurrence

Panel Members

Lee V. Gossick, Chairman	Executive Director for Operations
William J. Dircks, Vice Chairman	Director, Office of Nuclear Material Safety & Safeguards
Robert B. Minogue, Chairman of ENO Harrisburg Hearing Panel	Director, Office of Standards Development
Harold R. Denton	Director, Office of Nuclear Reactor Regulation
Saul Levine	Director, Office of Nuclear Regulatory Research
Howard K. Shapar	Executive Legal Director
Victor Stello, Jr.	Director, Office of Inspection and Enforcement

Alternate Panel Members

Ray G. Smith	Acting Deputy Executive Director for Operations
Edson G. Case	Deputy Director, Office of Nuclear Reactor Regulation
Robert Budnitz	Deputy Director, Office of Nuclear Regulatory Research
Thomas F. Engelhardt	Deputy Executive Legal Director
Dudley Thompson	Acting Deputy Director, Office of Inspection and Enforcement

Working Group

Jerome Saltzman, Chairman	Chief, Antitrust and Indemnity Group Office of Nuclear Reactor Regulation
Robert J. Bores	Radiation Specialist, Region I, Fuel Faclity and Materials Safety Branch Office of Inspection and Enforcement
Frank Congel	Leader, Radiological Impact Section Division of Site Safety and Environmental Analysis, Office of Nuclear Reactor Regulation
Ira Dinitz	Indemnity Specialist, Antitrust and Indemnity Group, Office of Nuclear Reactor Regulation
Guy H. Cunningham	Director and Chief Counsel,Office of Executive Legal Director
William E. Kreger	Assistant Director for Site Analysis Division of Site Safety and Environmental Analysis, Office of Nuclear Reactor Regulation
Walter J. Pasciak	Environmental Scientist, Radiological Impact Section, Division of Site Safety and Environmental Analysis, Office of Nuclear Reactor Regulation
Harold T. Peterson, Jr.	Senior Environmental Physicist, Radiological Health Standards Branch, Office of Standards Development
Marc R. Staenberg	Attorney, Office of Executive Legal Director
John P. Stohr	Chief, Radiation Support Section, Region I, Fuel Facility and Materials Safety Branch, Region I Office of Inspection and Enforcement

APPENDIX B

Selected Materials Pertaining to the ENO Panel

1. Federal Register Notice, July 23, 1979 (44 FR 43128)

2. Press Release, "NRC Invites Public to Submit Information to Assist in Determination on Three Mile Island," No. 79-121, July 20, 1979.

3. Federal Register Notice, September 7, 1979 (44 FR 52391)

4. Federal Register Notice, November 6, 1979 (44 FR 64133)

5. Press Release, "NRC to Hold Hearing November 21 in Harrisburg Concerning Determination on Three Mile Island Accident," No. 79-196, November 6, 1979

6. Meeting Report - Committee of Agency Representatives to Determine the Need for Further Reassessment of Population Doses (Three Mile Island Accident) November 28, 1979.

Financial Protection Requirements and Indemnity Agreements; Section 82—Procedures

Pursuant to its authority under Section 11(j) of the Atomic Energy Act of 1954, as amended, 42 U.S.C. 2014(j), and according to § 140.82 of its regulations, 10 CFR 140.82, the Commission hereby initiates the making of a determination as to whether or not the recent accident at Three Mile Island, Unit 2, constitutes an extraordinary nuclear occurrence ("ENO"). Although no petitions requesting such a determination have as yet been received, the Commission is aware of several factors which indicate that proceeding with the determination at this time is in the public interest. First, it is clear that the events which have taken place at Three Mile Island, Unit 2, constitute the most serious nuclear accident to date at a licensed U.S. facility, and thus should be rigorously scrutinized from the standpoint of their effect on the public. Second, various lawsuits have been brought concerning this accident, and the determination of whether or not an extraordinary nuclear occurrence has taken place is pertinent to issues which may arise in those cases. The court has informally asked the Commission for its view on the ENO question, and the Commission would like to assist the court in this regard.

The Commission invites interested persons to submit to the Commission, within thirty days of this announcement, any information in their possession relevant to this determination. Submittals should, if possible, focus on the application of the Commission's regulations, 10 CFR 140.84 and 140.85, to the consequence of the Three Mile Island, Unit 2, accident. This information, along with other information assembled by the Commission from its own and other sources, will be considered by a panel composed of Commission principal staff as required by 10 CFR 140.82(b). The composition of this panel, and the detailed procedures which the Commission proposes to follow, including further provision for public participation, will be announced at a later date. Submittals should be sent to the Secretary of the Commission, U.S. Nuclear Regulatory Commission, 1717 H Street, NW., Washington, D.C., 20555.

Contact: Ira P. Dinitz, 301-492-8336.

Dated at Washington, D.C., this 8th day of July 1979.

For the Commission.

Samuel J. Chilk,

Secretary of the Commission.

Background Information

Introduction

If a nuclear incident occurs, one of the principal obstacles to a claimant's recovery for injuries or damages could be the necessity of proving negligence on the part of the utility or other defendants. In 1966 Congress attempted to remove this obstacle for certain nuclear incidents ("extraordinary nuclear occurrences"—ENO) through contractual provisions termed "waivers of defenses," resulting in an essentially no-fault scheme. These waivers were intended to expedite recovery for claims under the Price-Anderson Act in the event of an ENO. The following is intended to explain the waiver of defenses in greater detail and to describe the criteria used by the NRC in making a finding as to whether or not an ENO has occurred. In order to better understand the waiver provision and the concept of an ENO, an overview of the Price-Anderson Act is included.

I. Overview of the Price-Anderson Act. Under the Price-Anderson Act, (which is a part of the Atomic Energy Act of 1954) there is a system of private funds and government indemnity totalling $560 million to pay public liability claims for personal injury and property damage resulting from a "nuclear incident." The Price-Anderson Act, which expires August 1, 1987, requires licensees of large commercial nuclear power plants to provide proof to the NRC that they have financial protection in the form of private nuclear liability insurance, or in some other form approved by the Commission, in an amount equal to the maximum amount of liability insurance available from private sources. That financial protection, $475 million at the time of the Three Mile Island (TMI) accident on March 28, 1979, consists of primary private nuclear liability insurance of $140 million provided by two insurance pools, American Nuclear Insurers (ANI) and Mutual Atomic Energy Liability Underwriters (MAELU) (which was increased to $160 million on May 1, 1979—except for TMI) and a secondary layer. In the event of a nuclear incident causing damages exceeding $140 million, each commercial nuclear power plant licensee would be charged by the insurance pools providing the insurance a prorated share of damages in excess of the primary insurance layer up to $5 million per reactor per incident. With 67 large commercial reactors now operating under this system, the secondary insurance layer totals $335 million. Thus, the two layers of insurance at the time of the TMI accident totaled $475 million. The difference of $85 million between the financial protection layers of $475 million and the $560 million liability limit established by the Price-Anderson Act is provided by government indemnity. Government indemnity will gradually be phased out as more commercial reactors are licensed and licensees participate in the second layer of insurance. When the primary and secondary layers by themselves provide liability coverage of $560 million, government indemnity will be eliminated. The liability limit—now $560 million—would thereafter increase in increments of $5 million for each new commercial reactor licensed to operate.

II. Extraordinary Nuclear Occurrence—General. A. *Definition.* Webster defines the term "extraordinary" as "going beyond what is usual, regular, or customary." Viewed in this light, the recent events at Three Mile Island may be termed extraordinary, since they would not occur during normal operations at a nuclear power plant. However, the term "extraordinary nuclear occurrence" (ENO) is precisely defined by the Price-Anderson Act as follows:

> The term "extraordinary nuclear occurrence" means any event causing a discharge or dispersal of source, special nuclear, or byproduct material from its intended place of confinement in amounts offsite, or causing radiation levels offsite, which the Commission determines to be substantial, and which the Commission determines has resulted or probably will result in substantial damages to persons offsite or property offsite. (Atomic Energy Act (as amended), subsection 11j, 42 U.S.C. 2014j)

The definition thus provides a two-pronged test: (1) Substantial offsite release of radioactive material or substantial offsite radiation, *and* (2) substantial offsite damages. This same section requires that the Commission "establish criteria in writing" for purposes of applying these tests to specific events.

The significance of the ENO concept is that a positive determination that an ENO has taken place must be made by the Commission before the "waiver of defenses" provisions of the Act, described below, can apply to the accident. In the event of a "nuclear incident" that is declared *not* to be an ENO, Price-Anderson funds are still available and normal defenses permitted under State law are not waived. The insurance pools may dispense funds under their policies, whether or not there is a determination by the Commission of an ENO, and in certain situations at TMI have already done so.

B. *Legislative History.* Congressional reports and statements by members of Congress in 1966, during the passage of the ENO and related provisions, give a clear impression of Congressional intent. On one hand, it was felt that if recovery of Price-Anderson funds were left entirely to the statutes and principles of State tort law in the event of a major nuclear accident, many valid claims might be tied up in the courts for years. Congress gave particular attention to problems of varying State statutes of limitations (some States, for example, had not adopted the "discovery" rule for concealed injuries—which would run the statute of limitations from the time the injured party knew of or reasonably should have discovered his injury). Congress was also concerned with the possibility that some States might not apply "strict liability" to a nuclear accident so that injured parties might have to prove negligence. On the other hand, there was considerable resistance to the total substitution of State law by creation of a "Federal tort" for nuclear accidents.

The result of this balance of competing factors was the "waiver" system. Under this system the NRC could require that its licensees agree to waive certain State law defenses (contributory negligence, assumption of risk, etc.) as part of the indemnity and insurance agreements, and thus create "strict liability" through the insurance policies and indemnity agreements. A statute of limitations would also be incorporated into these agreements, which would come into play if state statute of limitations were more restrictive. Finally, a consolidated Federal court proceeding would be used to handle all claims in the new system.

Insurers feared, however, that under such a waiver system they would be subjected to "nuisance suits." The insurance industry felt that it should not be required to waive the usual defenses available to it under State tort law for those "nuclear incidents" which had resulted in, at most, minor offsite releases and property damage. The insurance pools urged that such cases could be, and should be, dealt with within the usual State tort law system, particularly since minor accidents would not give rise to the need for quick, massive recoveries.

To meet this concern, Congress developed the "ENO" concept. The waiver provisions would be activated only if an "extraordinary nuclear occurrence" took place. The ENO was intended to be an event causing *both* substantial offsite releases of radiation and substantial offsite damages to persons or property. The Commission was given broad discretion (free of judicial review) to determine what constitutes an ENO, but was required by the 1966 amendments to publish written criteria which would be adopted after a public rulemaking process.

Congressional statements indicate that application of the criteria would be relatively flexible, even though precise numbers (such as a $5 million damage figure) would be selected in the rulemaking. There is no indication that Congress intended the Commission to apply its criteria in a rigid fashion. Still, it is equally clear that Congress did desire a reasonably specific index of what the Commission considered "substantial" for purposes of an ENO determination.

C. *Waivers of Defenses.* When the Commission determines that an ENO has occurred, then any defendant must waive:

(1) Any issue or defense as to the conduct of the claimant or fault of persons indemnified,

(ii) Any issue or defense, as to charitable or governmental immunity, and

(iii) Any issue or defense based on any statute of limitations if suit is instituted within three years from the date on which the claimant first knew, or reasonably could have known, of his injury or damage and the cause thereof but in no event more than twenty years after the date of the nuclear incident.

The waivers in subsection (i) relating to the fault of all persons indemnified relieve the claimant of having to prove negligence by any defendant and of having to disprove defenses such as contributory negligence. To recover for damages resulting from an ENO, a claimant needs to prove that he was injured or damaged, the monetary amount of the damages, and the causal link between his damages and the radioactive, toxic, explosive or other hazardous properties of the radioactive material released. Thus, through this "no-fault" type of provision the principal obstacle to a claimant's recovery is no longer proving negligence on the part of the defendant but rather showing that his injury or damage was caused by the ENO.

The statute of limitations provision in subsection (iii) of the waivers is not intended to be more restrictive than applicable State law. Thus, if a State had a statute of limitations which provided that suits for personal injury or property damage resulting from a nuclear incident could be brought any time within 30 years after the occurrence of the incident, the 30-year statute would take precedence over the 20-year period specified in the Price-Anderson Act.

The criteria to be used by the Commission will be fully discussed later, but at this point it should be reiterated that, unless an ENO is declared by the Commission, the waivers of defenses provisions do not apply. In such a situation a claimant would have exactly the same rights that he now has under existing tort law.

The other major concept in the 1966 amendments is that the Commission's authority to determine whether or not an ENO has occurred is not reviewable by the courts.

The 1966 amendments also benefited injured persons in several other respects. The Commission was authorized to make financial assistance payments to claimants immediately following a nuclear incident, regardless of whether an ENO determination has been made and without requiring them to sign a release or otherwise compromise their claims. In the event of an ENO, the 1966 amendments authorized all claimants to sue in the same Federal district court, generally under the same rules of procedure. Any action dealing with the same incident but pending in any State court or other Federal district court could, upon motion of the NRC or defendant, be removed to the single specified district court. Consolidation of all claims resulting from an ENO in a single Federal district court would permit all claimants to be treated equally. Finally, the 1966 amendments modified the Act to assure that available funds would be distributed in accordance with a court-approved plan making appropriate allowance for latent injury claims if it appeared that the total amount of all claims might exceed the limit on liability.

III. Criteria for Determining an ENO

A. *Language and Structure of the Criteria.* For the Commission to make the determination that there has been an ENO both Criterion I and Criterion II as set out in the Commission's published regulations (Title 10, Code of Federal Regulations, §§ 140.84 and 140.85) must be met. The language of the criteria (especially Criterion I) is rather technical and precise and is expressed in terms of measurements that laymen would not be expected to make themselves. For example, to satisfy Criterion I the Commission must determine that there has been a substantial discharge or dispersal of radioactive material off the site of the reactor, or that there has been a substantial level of radiation offsite. The Commission would determine that Criterion I had been met when, as a result of an event comprised of one or more related happenings, radioactive material is released from its intended place of confinement or radiation levels occur offsite and *either* of the following findings are also made.

a. The Commission finds that one or more persons offsite were, could have been, or might be exposed to radiation or to radioactive material, resulting in a dose or in a projected dose in excess of one of the levels in the following table:

Total Projected Radiation Doses

Critical organ	*Dose (rems)*
Thyroid	30
Whole body	20
Bone Marrow	20
Skin	60
Other organs or tissues	30

In measuring or projecting doses, exposures from the following types of radiation shall be included:

(1) Radiation from sources external to the body;

(2) Radioactive material that may be taken into the body from air or water; and

(3) Radioactive material that may be taken into the body from food or from land surfaces.

(or)

b. The Commission finds that—

(1) As the result of a release of radioactive material from a reactor there is at least a total of any 100 square meters of offsite property that has surface contamination. This contamination must show levels of radiation in excess of one of the values listed in column 1 or column 2 of the following table; *or*

(2) As the result of a release of radioactive material in the course of transportation surface contamination of any offsite property has occurred. This contamination must show levels of radiation in excess of one of the values listed in column 2 of the following table.

Total Surface Contamination Levels[1]

Type of emitter	Column 1 Utility's property beyond the fence surrounding the reactor station	Column 2 Other offsite property
Alpha emmission from transuranic isotopes	3.5 microcuries per square meter	0.35 microcuries per square meter.
Alpha emmission from isotopes other than transuranic isotopes	35 microcuries per square meter	3.5 microcuries per square meter.
Beta or gamma emmission	40 millirads/hour at 1 cm (measured through not more than 7 milligrams per square centimeter of total absorber)	4 millirads/hour at 1 cm (measured through not more than 7 milligrams per square centimeter of total absorber)

[1]The maximum levels (above background), observed or projected, 8 or more hours after initial deposition.

Based on the information available to the NRC staff at this time, it appears that neither part of Criterion I is satisfied. Both personal, exposures and property contamination are presently considered to be far below the levels specified in the tables set out above. In the period March 28–April 7, the approximate upper limit on whole body dose to a person in a populated area offsite has been calculated to be 100 millirems. For the most part, property contamination levels measured approximated "minimum detectable activity" levels.

If the Commission determines that an event satisfied Criterion I, Criterion II must then be applied. If Criterion I cannot reasonably be met, the Commission would conclude that there has not been an ENO. Criterion II is satisfied if the Commission makes *any* of the following findings:

(1) The event has resulted in the death or hospitalization, within 30 days of the event, of five or more people located offsite showing objective clinical evidence of physical injury from exposure to the radioactive, toxic, explosive or other hazardous properties the reactor's nuclear material: *or*

(2) $2,500,000 or more of damage offsite has been or will probably be sustained by any one person, or $5 million or more of such damage in total has been or will probably be sustained, as the result of such event; *or*

(3) The Commission finds that $5,000 or more of damage offsite has been or will probably be sustained by each of 50 or more persons, provided that $1 million or more of such damage in total has been or will probably be sustained, as the result of such event.

The term "damage" refers to damage arising out of or resulting from the radioactive, toxic, explosive, or other hazardous properties of the reactor's nuclear material, and shall be based upon estimates of one or more of the following:

(1) Total cost necessary to put affected property back into use,

(2) Loss of use of affected property,

(3) Value of affected property where not practical to restore to use,

(4) Financial loss resulting from protective actions such as evacuation, appropriate to reduce or avoid exposure to radiation or to radioactive materials.

Based on the information available to the NRC staff at this time, the only category of Criterion II damages possibly satisfied by the Three Mile Island accident is defined by (4), namely financial loss resulting from protective actions such as evacuation, appropriate to reduce or avoid exposure to radiation or radioactive material. A limited number of persons (pregnant women and small children) were advised by the Governor of Pennsylvania to leave the 5 mile radius of Three Mile Island, and in so doing incurred expenses. The insurance pools have been compensating the expenses of these families. Many others evacuated the area although they were not advised to do so.

A detailed assessment of all losses of this type might reach the $5 million figure of Criterion II, though much would depend on how broadly the various damage categories of this criterion were interpreted. It appears unlikely that voluntary payments by the insurance pools will reach this figure. The amount recoverable in the various court actions is virtually impossible to estimate at this time.

The 1966 amendments to the Act required the Commission to prepare and publish for public comment the criteria it proposed to apply in deciding whether a nuclear incident was an ENO. On May 9, 1968, the proposed rule and accompanying explanation appeared in the Federal Register (33 FR 6978). Following a period of public comment, the final rule was published on September 1, 1968 with an effective date of December 1, 1968 (33 FR 15998).

The dual criteria contained in the final rule were designed to follow the language of the 1966 amendments to the Act in defining an ENO: there must be a substantial offsite release *and* substantial offsite damages. The specific values incorporated into the criteria intentionally place a large gap between an ENO and the Commission's regulations governing offsite release during normal operations. Those values were intended to represent the Atomic Energy Commission's best judgment in deciding when the Act's definition of an ENO had been satisfied. The criteria have remained unchanged since their adoption in 1968.

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NEWS RELEASES

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Tel. 301/492-7715

FOR IMMEDIATE RELEASE
(Mailed - July 17, 1979)

NRC PUBLISHES PROPOSED RULE CHANGES IN ANTICIPATION OF US/IAEA SAFEGUARDS AGREEMENT

The Nuclear Regulatory Commission is republishing for public comment proposed new regulations which would implement the United States/International Atomic Energy Agency (IAEA) Safeguards Agreement when it becomes effective.

In 1967, the United States volunteered to have IAEA safeguards applied to all major U.S. nuclear activities with the exception of those having direct national security significance. This offer was made to encourage the widest possible adherence to the Treaty on the Non-Proliferation of Nuclear Weapons, by demonstrating to other nations that they would not be placed at a commercial disadvantage by application of safeguards under the treaty. The offer also was a manifestation of U.S. support of the international safeguards system and demonstrated the U.S. belief that IAEA safeguards would not interfere with peaceful nuclear activities.

Following formal negotiations between the U.S. and the IAEA, the IAEA Board of Governors approved the proposed US/IAEA Safeguards Agreement on September 17, 1976. The agreement has been submitted to the U.S. Senate for its advice and consent to ratification as a treaty.

The implementing regulations are contained in a proposed new Part 75 of NRC regulations, "Safeguards on Nuclear Material--Implementation of US/IAEA Agreement" and amendments to Parts 40, 50, 70, 150 and 170. They include provisions to permit IAEA inspection of certain licensed installations; a requirement for licensees to prepare and submit information about their installations; provisions for the NRC to transfer such information to the IAEA subject to special precautions in case of proprietary or other sensitive information; a requirement for submitting reports required by the Agency; and requirements for material accounting and control.

The proposed regulations were first published for public comment in May of 1978. The following November the Commission announced the availability of some supplemental documents and extended the public comment period for another 30 days.

Consideration of the comments has resulted in substantial changes to the original proposal. The Commission has decided to republish the proposed rule, with changes, for the purpose of affording further opportunity for licensee participation in formulating the policies and procedures that will apply to their activities.

Written comments or suggestions on the proposed rules should be sent by (45 days after FR publication), to the Secretary of the Commission, Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Docketing and Service Branch. The text of the proposed implementing regulations is being published in the Federal Register on July 17, 1979.

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No. 79-121
Tel. 301/492-7715
215/337-5330

FOR IMMEDIATE RELEASE
(Friday, July 20, 1979)

NRC INVITES PUBLIC TO SUBMIT INFORMATION TO ASSIST IN DETERMINATION ON THREE MILE ISLAND ACCIDENT

The Nuclear Regulatory Commission is inviting the public to submit information which will assist the Commission in determining whether the waivers of defenses provisions of the Price-Anderson Act should be applied in lawsuits involving the March 28 accident at the Three Mile Island Nuclear Power Plant in Pennsylvania.

The Price-Anderson Act provides a system of private funds and government indemnity totaling $560 million to pay public liability claims for personal injury and property damage resulting from a nuclear incident.

In order to conclude that the waivers of defenses provisions of the Price-Anderson Act apply, the Commission would have to make two specific findings in regard to the accident at Three Mile Island. The first is that there was a substantial release of radioactive material offsite. This involves either radiation doses received by individuals or radiation levels on specific areas of land. The second finding is that there were substantial offsite damages. The levels of offsite radiation and the damage amounts required by the Commission's existing regulations are discussed in the attachment to this announcement.

If the Commission were to make these findings, the defendants in the Three Mile Island lawsuits would be required to waive certain defenses they otherwise might have. To recover damages a claimant would not need to prove negligence. The claimant would only need to prove injury or damage, the monetary amount of the damages and that the damages were caused by the accident.

The waivers eliminate certain defenses based upon the conduct of the claimant, such as contributory negligence and assumption of risk. There also are provisions concerning the statute of limitations and the consolidation of suits in a single Federal District Court.

The NRC staff has advised the Commission that based on the information available at this time it does not believe the criteria necessary to activate the waivers of defenses have been met; in particular, the radiation released appears to be several hundred times less than that required to meet the criterion in the regulations. However, the Commission believes more information should be sought from the public and other sources.

The Commission said that although no petitions have been received requesting that the Price-Anderson findings be made, there are several factors which make such a determination a matter of public interest. First, the accident at Three Mile Island is the most serious nuclear accident to date at a licensed U.S. facility, and thus should be scrutinized rigorously from the standpoint of its effect on the public. Secondly, various lawsuits have been brought as a result of the accident, and a determination by the Commission is pertinent to issues which may arise in those cases. The Federal District Court in Harrisburg has informally asked the Commission for its view on this matter, and the Commission would like to assist the Court.

American Nuclear Insurers has advised the NRC that it has been paying claims for living expenses of pregnant women and pre-school age children who evacuated the five-mile area following the March 28 accident for the period covered by Governor Richard Thornburgh's advisory. Payments were also made to husbands and other family members of the affected individuals who chose to evacuate with them. The decision to pay claims for expenses of other persons living within the five-mile area not covered by the Governor's advisory to pregnant women and pre-school age children--such as those filed by persons with special medical problems who would have had extreme difficulty evacuating the area on short notice and who therefore chose not to stay--was made on a case-by-case basis.

As of June 28, cumulative payments for evacuation made to approximately 10,000-12,000 individuals were $1,275,072. To date, twenty legal actions have been initiated in Pennsylvania State and Federal courts. All of these cases are now pending before the Federal District Court in Harrisburg. Additional claims have been received by American Nuclear Insurers from individuals and businesses both within and outside the five-mile radius of the plant, claiming damages for personal injury loss of use and value of property, and business losses resulting from the accident. ANI reports it still is reviewing those claims.

In its request for public comment, the Commission invited interested persons to submit, within 30 days, any information relevant to making the "extraordinary nuclear occurrence" determination under the Price-Anderson Act and to focus, if possible, on the application of Sections 140.84 and 140.85 of NRC regulations with respect to the Three Mile Island accident. These provisions, together with other information on the subject, are described in the attachment to this announcement. Information provided by the public, along with information assembled by the Commission from its own and other sources, will be considered by a panel composed of NRC principal staff. The composition of this panel, and the detailed procedures which the Commission will follow, including further provision for public participation, will be announced later.

Submittals should be sent to the Secretary, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555. Copies of these submittals will be placed in the NRC Public Document Room, 1717 H Street, NW, Washington, D.C., and in the local public document room in the Government Publications Section, State Library of Pennsylvania, Commonwealth and Walnut Streets, Harrisburg.

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NOTE TO EDITORS: Members of the public may obtain this information package at the main post office in Harrisburg, Lancaster, York, Middletown, Elizabethtown and Etters, PA.

Attachment

BACKGROUND INFORMATION

INTRODUCTION

If a nuclear incident occurs, one of the principal obstacles to a claimant's recovery for injuries or damages could be the necessity of proving negligence on the part of the utility or other defendants. In 1966 Congress attempted to remove this obstacle for certain nuclear incidents ("extraordinary nuclear occurrences" - ENO) through contractual provisions termed "waivers of defenses," resulting in an essentially no-fault scheme. These waivers were intended to expedite recovery for claims under the Price-Anderson Act in the event of an ENO. The following is intended to explain the waiver of defenses in greater detail and to describe the criteria used by the NRC in making a finding as to whether or not an ENO has occurred. In order to better understand the waiver provision and the concept of an ENO, an overview of the Price-Anderson Act is included.

I. OVERVIEW OF THE PRICE-ANDERSON ACT

Under the Price-Anderson Act (which is a part of the Atomic Energy Act of 1954) there is a system of private funds and government indemnity totalling $560 million to pay public liability claims for personal injury and property damage resulting from a "nuclear incident." The Price-Anderson Act, which expires August 1, 1987, requires licensees of large commercial nuclear power plants to provide proof to the NRC that they have financial protection in the form of private nuclear liability insurance, or in some other form approved by the Commission, in an amount equal to the maximum amount of liability insurance available from private sources. That financial protection, $475 million at the time of the Three Mile Island (TMI) accident on March 28, 1979, consists of primary private nuclear liability insurance of $140 million provided by two insurance pools, American Nuclear Insurers (ANI) and Mutual Atomic Energy Liability Underwriters (MAELU) (which was increased to $160 million on May 1, 1979 -- except for TMI) and a secondary layer. In the event of a nuclear incident causing damages exceeding $140 million, each commercial nuclear power plant licensee would be charged by the insurance pools, providing the insurance a prorated share of damages in excess of the primary insurance layer up to $5 million per reactor per incident. With 67 large commercial reactors now operating under this system, the secondary insurance layer totals $335 million. Thus, the two layers of insurance at the time of the TMI accident totaled $475 million. The difference of $85 million between the financial protection layers of $475 million and the $560 million liability limit established by the Price-Anderson Act is provided by government indemnity. Government indemnity will gradually be phased out as more commercial reactors are licensed and licensees participate in the second layer of insurance. When the primary and secondary layers by themselves provide liability coverage of $560 million, government indemnity will be eliminated. The liability limit -- now $560 million -- would thereafter increase in increments of $5 million for each new commercial reactor licensed to operate.

II. EXTRAORDINARY NUCLEAR OCCURRENCE -- GENERAL

A. Definition

Webster defines the term "extraordinary" as "going beyond what is usual, regular, or customary." Viewed in this light, the recent events at Three Mile Island may be termed extraordinary, since they would not occur during normal operations at a nuclear power plant. However, the term "extraordinary nuclear occurrence" (ENO) is precisely defined by the Price-Anderson Act as follows:

> The term "extraordinary nuclear occurrence" means any event causing a discharge or dispersal of source, special nuclear, or byproduct material from its intended place of confinement in amounts offsite, or causing radiation levels offsite, which the Commission determines to be substantial, and which the Commission determines has resulted or probably will result in substantial damages to persons offsite or property offsite. (Atomic Energy Act (as amended), subsection 11j, 42 U.S.C. 2014j)

The definition thus provides a two-pronged test: (1) substantial offsite release of radioactive material or substantial offsite radiation, and (2) substantial offsite damages. This same section requires that the Commission "establish criteria in writing" for purposes of applying these tests to specific events.

The significance of the ENO concept is that a positive determination that an ENO has taken place must be made by the Commission before the "waiver of defenses" provisions of the Act, described below, can apply to the accident. In the event of a "nuclear incident" that is declared not to be an ENO, Price-Anderson funds are still available and normal defenses permitted under State law are not waived. The insurance pools may dispense funds under their policies, whether or not there is a determination by the Commission of an ENO, and in certain situations at TMI have already done so.

B. Legislative History

Congressional reports and statements by members of Congress in 1966, during the passage of the ENO and related provisions, give a clear impression of Congressional intent. On one hand, it was felt that if recovery of Price-Anderson funds were left entirely to the statutes and principles of State tort law in the event of a major nuclear accident, many valid claims might be tied up in the courts for years. Congress gave particular attention to problems of varying State statutes of limitations (some States, for example, had not adopted the "discovery" rule for concealed injuries -- which would run the statute of limitations from the time the injured party knew of or reasonably should have discovered his injury). Congress was also concerned with the possibility that some States might not apply "strict liability" to a nuclear accident so that injured parties might have to prove negligence. On the other hand, there was considerable resistance to the total substitution of State law by creation of a "Federal tort" for nuclear accidents.

The result of this balance of competing factors was the "waiver" system. Under this system the NRC could require that its licensees agree to waive certain State law defenses (contributory negligence, assumption of risk, etc.) as part of the indemnity and insurance agreements, and thus create "strict liability" through the insurance policies and indemnity agreements. A statute of limitations would also be incorporated into these agreements, which would come into play if state statute of limitations were more restrictive. Finally, a consolidated Federal court proceeding would be used to handle all claims in the new system.

Insurers feared, however, that under such a waiver system they would be subjected to "nuisance suits." The insurance industry felt that it should not be required to waive the usual defenses available to it under State tort law for those "nuclear incidents" which had resulted in, at most, minor offsite releases and property damage. The insurance pools urged that such cases could be, and should be, dealt with within the usual State tort law system, particularly since minor accidents would not give rise to the need for quick, massive recoveries.

To meet this concern, Congress developed the "ENO" concept. The waiver provisions would be activated only if an "extraordinary nuclear occurrence" took place. The ENO was intended to be an event causing both substantial offsite releases of radiation and substantial offsite damages to persons or property. The Commission was given broad discretion (free of judicial review) to determine what constitutes an ENO, but was required by the 1966 amendments to publish written criteria which would be adopted after a public rulemaking process.

Congressional statements indicate that application of the criteria would be relatively flexible, even though precise numbers (such as a $5 million damage figure) would be selected in the rulemaking. There is no indication that Congress intended the Commission to apply its criteria in a rigid fashion. Still, it is equally clear that Congress did desire a reasonably specific index of what the Commission considered "substantial" for purposes of an ENO determination.

C. Waivers of Defenses

When the Commission determines that an ENO has occurred, then any defendant must waive:

(i) any issue or defense as to the conduct of the claimant or fault of persons indemnified,

(ii) any issue or defense, as to charitable or governmental immunity, and

(iii) any issue or defense based on any statute of limitations if suit is instituted within three years from the date on which the claimant first knew, or reasonably could have known, of his injury or damage and the cause thereof, but in no event more than twenty years after the date of the nuclear incident.

The waivers in subsection (i) relating to the fault of all persons indemnified relieve the claimant of having to prove negligence by any defendant and of having to disprove defenses such as contributory negligence. To recover for damages resulting from an ENO, a claimant needs to prove that he was injured or damaged, the monetary amount of the damages, and the causal link between his damages and the radioactive, toxic, explosive or other hazardous properties of the radioactive material released. Thus, through this "no-fault" type of provision the principal obstacle to a claimant's recovery is no longer proving negligence on the part of the defendant but rather showing that his injury or damage was caused by the ENO.

The statute of limitations provision in subsection (iii) of the waivers is not intended to be more restrictive than applicable State law. Thus, if a State had a statute of limitations which provided that suits for personal injury or property damage resulting from a nuclear incident could be brought any time within 30 years after the occurrence of the incident, the 30-year statute would take precedence over the 20-year period specified in the Price-Anderson Act.

The criteria to be used by the Commission will be fully discussed later, but at this point it should be reiterated that, unless an ENO is declared by the Commission, the waivers of defenses provisions do not apply. In such a situation a claimant would have exactly the same rights that he now has under existing tort law.

The other major concept in the 1966 amendments is that the Commission's authority to determine whether or not an ENO has occurred is not reviewable by the courts.

The 1966 amendments also benefited injured persons in several other respects. The Commission was authorized to make financial assistance payments to claimants immediately following a nuclear incident, regardless of whether an ENO determination has been made and without requiring them to sign a release or otherwise compromise their claims. In the event of an ENO, the 1966 amendments authorized all claimants to sue in the same Federal district court, generally under the same rules of procedure. Any action dealing with the same incident but pending in any State court or other Federal district court could, upon motion of the NRC or defendant, be removed to the single specified district court. Consolidation of all claims resulting from an ENO in a single Federal district court would permit all claimants to be treated equally. Finally, the 1966 amendments modified the Act to assure that available funds would be distributed in accordance with a court-approved plan making appropriate allowance for latent injury claims if it appeared that the total amount of all claims might exceed the limit on liability.

III. CRITERIA FOR DETERMINING AN ENO

A. Language and Structure of the Criteria

For the Commission to make the determination that there has been an ENO both Criterion I and Criterion II as set out in the Commission's published regulations (Chapter 10, Code of Federal Regulations, sections 140.84 and 140.85) must be met. The language of the criteria (especially Criterion I) is rather technical and precise and is expressed in terms of measurements that laymen would not be expected to make themselves. For example, to satisfy Criterion I the Commission must determine that there has been a substantial discharge or dispersal of radioactive material off the site of the reactor, or that there has been a substantial level of radiation offsite. The Commission would determine that Criterion I had been met when, as a result of an event comprised of one or more related happenings, radioactive material is released from its intended place of confinement or radiation levels occur offsite and either of the following findings are also made.

a. The Commission finds that one or more persons offsite were, could have been, or might be exposed to radiation or to radioactive material, resulting in a dose or in a projected dose in excess of one of the levels in the following table:

TOTAL PROJECTED RADIATION DOSES

Critical organ	Dose (rems)
Thyroid	30
Whole body	20
Bone Marrow	20
Skin	60
Other organs or tissues	30

In measuring or projecting doses, exposures from the following types of radiation shall be included:

(1) Radiation from sources external to the body;

(2) Radioactive material that may be taken into the body from air or water; and

(3) Radioactive material that may be taken into the body from food or from land surfaces.

(or)

b. The Commission finds that --

(1) As the result of a release of radioactive material from a reactor there is at least a total of any 100 square meters of offsite property that has surface contamination. This contamination must show levels of radiation in excess of one of the values listed in column 1 or column 2 of the following table, or

(2) As the result of a release of radioactive material in the course of transportation surface contamination of any offsite property has occurred. This contamination must show levels of radiation in excess of one of the values listed in column 2 of the following table.

TOTAL SURFACE CONTAMINATION LEVELS*/

Type of emitter	Column 1 Utility's property beyond the fence surrounding the reactor station.	Column 2 Other offsite property
Alpha emmission from transuranic isotopes	3.5 microcuries per square meter	0.35 microcuries per square meter
Alpha emmission from isotopes other than transuranic isotopes	35 microcuries per square meter	3.5 microcuries per square meter
Beta or gamma emmission	40 millirads/hour at 1 cm. (measured through not more than 7 milligrams per square centimeter of total absorber)	4 millirads/hour at 1 cm. (measured through not more that 7 milligrams per square centimeter of total absorber)

*/ The maximum levels (above background), observed or projected, 8 or more hours after initial deposition.

Based on the information available to the NRC staff at this time, it appears that neither part of Criterion I is satisfied. Both personal exposures and property contamination are presently considered to be far below the levels specified in the tables set out above. In the period March 28-April 7, the approximate upper limit on whole body dose to a person in a populated area offsite has been calculated to be 100 millirems. For the most part, property contamination levels measured approximated "minimum detectable activity" levels.

If the Commission determines that an event satisfied Criterion I, Criterion II must then be applied. If Criterion I cannot reasonably be met, the Commission would conclude that there has not been an ENO. Criterion II is satisfied if the Commission makes any of the following findings:

(1) The event has resulted in the death or hospitalization, within 30 days of the event, of five or more people located offsite showing objective clinical evidence of physical injury from exposure to the radioactive, toxic, explosive or other hazardous properties the reactor's nuclear material; or

(2) $2,500,000 or more of damage offsite has been or will probably be sustained by any one person, or $5 million or more of such damage in total has been or will probably be sustained, as the result of such event; or

(3) The Commission finds that $5,000 or more of damage offsite has been or will probably be sustained by each of 50 or more persons, provided that $1 million or more of such damage in total has been or will probably be sustained, as the result of such event.

The term "damage" refers to damage arising out of or resulting from the radioactive, toxic, explosive, or other hazardous properties of the reactor's nuclear material, and shall be based upon estimates of one or more of the following:

(1) Total cost necessary to put affected property back into use,

(2) Loss of use of affected property,

(3) Value of affected property where not practical to restore to use,

(4) Financial loss resulting from protective actions such as evacuation, appropriate to reduce or avoid exposure to radiation or to radioactive materials.

Based on the information available to the NRC staff at this time, the only category of Criterion II damages possibly satisfied by the Three Mile Island accident is defined by (4), namely financial loss resulting from protective actions such as evacuation, appropriate to reduce or avoid exposure to radiation or radioactive material. A limited number of persons (pregnant women and small children) were advised by the Governor of Pennsylvania to leave the 5 mile radius of Three Mile Island, and in so doing incurred expenses. The insurance pools have been compensating the expenses of these families. Many others evacuated the area although they were not advised to do so.

A detailed assessment of all losses of this type might reach the $5 million figure of Criterion II, though much would depend on how broadly the various damage categories of this criterion were interpreted. It appears unlikely that voluntary payments by the insurance pools will reach this figure. The amount recoverable in the various court actions is virtually impossible to estimate at this time.

The 1966 amendments to the Act required the Commission to prepare and publish for public comment the criteria it proposed to apply in deciding whether a nuclear incident was an ENO. On May 9, 1968, the proposed rule and accompanying explanation appeared in the Federal Register (33 Fed. Reg. 6978). Following a period of public comment, the final rule was published on September 1, 1968 with an effective date of December 1, 1968 (33 Fed. Reg. 15998).

The dual criteria contained in the final rule were designed to follow the language of the 1966 amendments to the Act in defining an ENO: there must be a substantial offsite release and substantial offsite damages. The specific values incorporated into the criteria intentionally place a large gap between an ENO and the Commission's regulations governing offsite release during normal operations. Those values were intended to represent the Atomic Energy Commission's best judgment in deciding when the Act's definition of an ENO had been satisfied. The criteria have remained unchanged since their adoption in 1968.

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No. 79-122 FOR IMMEDIATE RELEASE
Contact: Frank L. Ingram (Mailed - July 17, 1979)
Tel. 301/492-7715

NRC CONSIDERING ADDITIONAL REGULATIONS ON EMERGENCY PLANS

The Nuclear Regulatory Commission is considering the adoption of additional regulations which would establish, as a condition of power reactor operation, increased emergency readiness for public protection in the vicinity of these facilities; such regulations would involve utility licensees as well as State and local authorities and the NRC.

The action is one of many being taken by the Commission in response to the March 28 accident at the Three Mile Island Nuclear Power Station and also is responsive to recommendations from the General Accounting Office and requests from a number of organizations including renewed and supplemental petitions for rulemaking from Critical Mass and Public Interest Research Groups.

The Commission is seeking public comment on the following subjects:

1. What should be the basic objectives of emergency planning? Reduce public radiation exposure? Prevent public radiation exposure? Capability to evacuate the public? To what extent should these objectives be quantified?

2. What constitutes an effective emergency response plan for State and local agencies and for NRC licensees? What are the essential elements that must be included in an effective plan? Do existing NRC requirements and guidance lack any of these essential elements?

3. Should NRC concurrence in the associated State and local emergency response plans be a requirement for continued operation of any nuclear power plant with an existing operating license? If so, when should this general requirement become effective?

4. Should prior NRC concurrence in the associated State and local emergency response plans be a requirement for the issuance of any new operating license for a nuclear power plant? If so, when should this general requirement become effective.

5. Should financial assistance be provided to State and local governments for radiological emergency response planning and preparedness? If so, to what extent and by what means? What should be the source of the funds?

6. Should radiological emergency response drills be a requirement? If so, under whose authority: Federal, State or local government? To what extent should Federal, State, and local governments, and licensees be required to participate?

7. How and to what extent should the public be informed, prior to any emergency, concerning emergency actions it might be called upon to take?

8. What actions should be taken in response to the recommendations of the joint NRC/EPA Task Force Report (NUREG-0396/EPA 520/1-78-016)?

9. Under what circumstances and using what criteria should a licensee notify State, local, and Federal agencies of incidents, including emergencies? When, how, to what extent, and by whom should the public be notified of these incidents?

The comments received will be collected and evaluated by the NRC staff, which will, in turn, submit recommendations on proposed rules to the Commission. Based on the comments it receives from the public and the analysis of the problem presented by the NRC Staff, the Commission will determine whether to proceed with a proposed rule for notice and comment and/or whether to make such rule immediately effective. The Commission anticipates completion of this expedited rulemaking in approximately six months.

The NRC staff is presently conducting a comprehensive review of all aspects of the NRC emergency planning and preparedness program. Therefore, the Commission is also interested in receiving comments on all other aspects of emergency planning, including issues raised in the Critical Mass/PIRG petition for rulemaking and questions such as the following:

10. How and to what extent should the concerns of State and local governments be incorporated into Federal radiological emergency response planning?

11. How should Federal agencies interface with State and local governments and the licensee during emergencies?

12. Should the licensees be required to provide radiological emergency response training for State and local government personnel? If so, to what extent? Should the Federal government provide such training? If so, to what extent?

13. To what extent should reliance be placed on licensees for the assessment of the actual or potential consequences of an accident with regard to initiation of protective action? To what extent should this responsibility be borne by Federal, State or local governments?

14. Would public participation in radiological emergency response drills, including evacuation, serve a useful purpose? If so, what should be the extent of the public participation?

Comments should be addressed to the Secretary of the Commission, Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Docketing and Service Branch within 45 days of publication in the Federal Register on July 17.

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No. 79-123 FOR IMMEDIATE RELEASE
Contact: Frank L. Ingram (Mailed - July 18, 1979)
Tel. 301/492-7715

NOTE TO EDITORS:

On June 15, the Nuclear Regulatory Commission announced that it was changing its regulations to provide for the protection of spent nuclear fuel in transit from one facility to another.

Among the shipments to which these new regulations apply are those involving used nuclear fuel imported from European research reactors for reprocessing in Department of Energy facilities at Savannah River, South Carolina.

At the present time, these shipments (about 60 in calendar year 1979) are transported by ship to Portsmouth, Virginia, where they are off-loaded and transhipped by truck to Savannah River.

As part of its effort to implement the new regulations, the NRC staff has surveyed other deep-water ports between Portsmouth and Savannah River to see if they have the technical capability to handle such shipments: these ports include Charleston and North Charleston, Savannah, Morehead City, and Wilmington.

This has led to news media speculation that the staff will require these shipments to enter the United States through a port closer to Savannah River than Portsmouth and/or that one of these ports will become a repository for nuclear waste.

In order to put this matter into perspective, it should be made clear that:

1. The NRC does not have a pending application for approval to import such shipments through any port except Portsmouth.

2. If such an application were received, among the requirements it would have to meet would be those governing the safeguarding of shipments of spent fuel at the port and in transit to the Savannah River Plant.

Technical Information and Document Control.

Dated at Rockville, MD this 31st day of August 1979.

For the U.S. Nuclear Regulatory Commission.

Guy A. Arlotto,

Director, Division of Engineering Standards, Office of Standards Development.

[FR Doc. 79-27870 Filed 9-6-79; 8:45 am]

BILLING CODE 7590-01-M

Sales Policy for Regulatory Guides

Since the Regulatory Guide Series was instituted in 1972, printing and distribution costs have greatly increased. In order to reduce the burden on the taxpayer, the Nuclear Regulatory Commission (NRC) has made arrangements with the U.S. Government Printing Office (GPO) to become a consigned sales agent for certain NRC publications. Effective October 1, 1979, regulatory guides are being included in this sales program and may be purchased on a subscription or individual copy basis. This program will ensure the continued use of regulatory guides in an efficient and cost-effective manner.

Draft guides will continue to be furnished at no cost to those on the current distribution list for the appropriate division. NRC licenses will receive, also at no cost, a single copy of pertinent draft and active regulatory guides as they are issued. Otherwise, active regulatory guides issued after September 30, 1979, will be sent only to those who have made arrangements for a paid subscription. Both draft and active guides will be available in the NRC Public Document Room at 1717 H Street NW., Washington, D.C., for inspection and copying for a fee.

In the past, the policy of minimizing the cost to the taxpayer has prevented NRC from furnishing multiple copies, either on a subscription basis or in response to requests for guides already issued. With the new sales arrangement, subscribers may purchase as many subscriptions for the future guides as they need. Requests for multiple copies of guides already issued will be filled at the current Government Printing Office price.

Information on the subscription service and current GPO prices may be obtained by writing the U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Publications Sales Manager.

(5 U.S.C. 552(a))

Dated at Rockville, Maryland this 29th day of August 1979.

For the Nuclear Regulatory Commission.

Robert B. Minogue,

Director, Office of Standards Development.

[FR Doc. 79-27871 Filed 9-6-79; 8:45 am]

BILLING CODE 7590-01-M

Financial Protection Requirements and Indemnity Agreements

On July 23, 1979, the Nuclear Regulatory Commission published in the Federal Register (44 FR 43128) a notice that pursuant to the Atomic Energy Act of 1954, as amended, the Commission was initiating the making of a determination as to whether or not the recent accident at Three Mile Island, Unit 2, (TMI-2) constitutes an extraordinary nuclear occurrence. The notice indicated the submittals of public comments, along with other information assembled by the Commission from its own and other sources will be considered by a panel composed of Commission principal staff.

This panel has now been formed with the Executive Director of Operations as Chairman. Members of the panel will be the Directors of the Office of Nuclear Reactor Regulation, Nuclear Material Safety and Safeguards, Nuclear Regulatory Research, Inspection and Enforcement, and Standards Development, and the Executive Legal Director. In addition, the present deputy of each member of the panel will serve as an alternate in order that the panel may continue its work during the temporary absence of one or more members. The Director of the Office of Nuclear Material Safety and Safeguards will serve as Deputy Chairman of the panel. The members of the panel will draw upon the personnel resources of their staff to assist in the completion of their work.

The panel intends to complete its work and report to the Commission as soon as possible after the panel has had an opportunity to review any information relevent to its review presented in the report of the Presidential Commission Investigating the TMI-2 accident. At the time it reports to the Commission it intends to publish its report in the Federal Register for public comment. The panel intends to review thoroughly all data provided by the public in the comment period that ended August 23. It also intends to review information provided by any other parties and to review and update as necessary the data and analyses provided by the numerous studies on offsite releases that it has identified as having been completed or underway.

Dated at Bethesda, Maryland this 30th day of August 1979.

For the Nuclear Regulatory Commission.

William J. Dircks,

Director of Nuclear Material Safety and Safeguards.

[FR Doc. 79-27880 Filed 9-6-79; 8:45 am]

BILLING CODE 7590-01-M

SMALL BUSINESS ADMINISTRATION

[Proposed License No. 09/09-0245]

Crosspoint Investment Corp.; Application for a License To Operate as a Small Business Investment Co.

Notice is hereby given of the filing of an application with the Small Business Administration pursuant to Section 107.102 of the Regulations governing small business investment companies (CFR 107.102(1979)), by Crosspoint Investment Corporation, 1015 Corporation Way, Palo Alto, California 94303, for a license to operate as a small business investment company (SBIC) under the provisions of the Small Business Investment Act of 1958, as amended (Act), (15 U.S.C. 101 et seq).

Officers, Directors and Shareholders

Joe D. Giulie, Chairman of the Board of Directors, 25295 La Loma, Los Altos Hills, California 94022.

Max S. Simpson, President and Chief Executive Officer, 1177 California Avenue, San Francisco, California 94108. 5 percent.

F. Allan Anderson, Director 839 Marina Boulevard; San Francisco, California 94108. 5 percent.

Kenneth A. Eldred, Director, 1875 Westridge, Portola Valley, California 94025. 5 percent.

John B. Mumford, Secretary, Chief Financial Officer and Director, 108 Kathy Court, Los Gatos, California 95030.

Crosspoint Financial Corporation, 1015 Corporation Way; Palo Alto, California. 85 percent.

The Applicant will start operations with $160,000 initial private capital. Crosspoint Financial Corporation has arranged to purchase the Applicant's shares in three $160,000 increments over the 18-month period from July 1, 1979, to December 31, 1980. Messrs. Joe D. Giulie and John B. Mumford, 50 percent and 40 percent owners, respectively, of Crosspoint Financial Corporation, will agree to assume the subscription to purchase the balance of the shares subscribed to in the event Crosspoint Financial Corporation is either unwilling or unable to purchase such stock on a demand basis or within 18-months. Messrs. Max S. Simpson, F. Allan Anderson and Kenneth A. Eldred have agreed that upon 30-day written notice by the Applicant, or if no demand is made then on September 30, 1980, they shall honor their subscription to

The relief consists of exemption from the requirements for measuring certain parameters in the Pump and Valve Testing Program and from performing certain pressure vessel weld inspections in the Inservice Inspection Testing Program.

The request for relief complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's rules and regulations. The Commission has made appropriate findings as required by the Act and the Commission's rules and regulations in 10 CFR Chapter I, which are set forth in the letter granting relief. Prior public notice of this action was not required since the granting of this relief from ASME Code requirements does not involve a significant hazards consideration.

The Commission has determined that the granting of this relief will not result in any significant environmental impact and that pursuant to 10 CFR § 51.5(d)(4) an environmental impact statement or negative declaration and environmental impact appraisal need not be prepared in connection with this action.

For further details with respect to this action, see (1) the request for relief dated February 28, 1979, (2) the Commission's letter to the licensee dated October 25, 1979.

The items are available for public inspection at the Commission's Public Document Room, 1717 H Street, N.W., Washington, D.C. and at the University of Wisconsin, Stevens Point Library, Stevens Point, Wisconsin 54481. A copy of item (2) may be obtained upon request addressed to the U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Director, Division of Operating Reactors.

Dated at Bethesda, Maryland, this 25th Day of October, 1979.

For the Nuclear Regulatory Commission.

A. Schwencer,

Chief, Operating Reactors Branch No. 1, Division of Operating Reactors.

[FR Doc. 79-34231 Filed 11-6-79; 8:45 am]

BILLING CODE 7590-01-M

Draft Regulatory Guide; Issuance and Availability

The Nuclear Regulatory Commission has issued for public comment a draft of a new guide planned for its Regulatory Guide Series together with a draft of the associated value/impact statement. This series has been developed to describe and make available to the public methods acceptable to the NRC staff of implementing specific parts of the Commission's regulations and, in some cases, to delineate techniques used by the staff in evaluating specific problems or postulated accidents and to provide guidance to applicants concerning certain of the information needed by the staff in its review of applications for permits and licenses.

The draft guide, temporarily identified by its task number, SG 901-4, is entitled "Reporting of Safeguards Events" and is intended for Division 5, "Materials and Plant Protection." The Commission recently published proposed amendments to its regulations in § 73.71 of 10 CFR Part 73, "Physical Protection of Plants and Materials," that would, if adopted, require licensees to report to appropriate offices within the Nuclear Regulatory Commission events that significantly threaten or lessen the effectiveness of their safeguards systems as established by safeguards regulations or by an approved safeguards plan or by both. This guide is being developed to provide an approach acceptable to the NRC staff for determining whether an event should be reported and the format that could be used for reporting the event.

This draft guide and the associated value/impact statement are being issued to involve the public in the early stages of the development of a regulatory position in this area. They have not received complete staff review and do not represent an official NRC staff position.

Public comments are being solicited on both drafts, the guide (including any implementation schedule) and the draft value/impact statement. Comments on the draft value/impact statement should be accompanied by supporting data. Comments on both drafts should be sent to the Secretary of the Commission, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Docketing and Service Branch, by December 31, 1979.

Although a time limit is given for comments on these drafts, comments and suggestions in connection with (1) items for inclusion in guides currently being developed or (2) improvements in all published guides are encouraged at any time.

Regulatory guides are available for inspection at the Commission's Public Document Room, 1717 H Street NW., Washington, D.C. Requests for single copies of draft guides (which may be reproduced) or for placement on an automatic distribution list for single copies of future draft guides in specific divisions should be made in writing to the U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Director, Division of Technical Information and Document Control. Telephone requests cannot be accommodated. Regulatory guides are not copyrighted, and Commission approval is not required to reproduce them.

(5 U.S.C. 552(a))

Dated at Rockville, Md., this 29th day of October 1979.

For the Nuclear Regulatory Commission.

Karl R. Goller,

Director, Division of Siting, Health and Safeguards Standards, Office of Standards Development.

[FR Doc. 79-34229 Filed 11-6-79; 8:45 am]

BILLING CODE 7590-01-M

Hearing To Receive Testimony on Whether the March 28, 1979, Accident At the Three Mile Island Unit 2 Reactor Should Be Considered an Extraordinary Nuclear Occurrence (ENO)

On July 23, 1979, the Nuclear Regulatory Commission published in the Federal Register (44 FR 43128) a notice that pursuant to the Atomic Energy Act of 1954, as amended, the Commission was initiating the making of a determination as to whether or not the March 28, 1979 accident at the Three Mile Island Unit 2 reactor (TMI-2) constitutes an extraordinary nuclear occurrence (ENO) as defined in the Commission's regulations, 10 CFR Part 140, §§ 140.84 and 140.85. On August 17, 1979 the Commission directed that a panel composed of members of the principal staff be formed to evaluate public comments received in connection with our July 23 notice and other technical information assembled by the Commission from its own and other sources. The panel is presently reviewing the comments provided by the public in response to the July 23 notice and reviewing and updating as necessary the data and analyses provided by the numerous studies on offsite releases that it has identified as having been completed or underway.

In the interest of compiling as complete a record as possible for making the ENO determination, the Commission has decided to grant a request for a public hearing filed by Mr. David Berger on August 29, 1979. A one-day informal hearing will be held in Harrisburg, Pennsylvania to provide interested members of the public the opportunity to present oral statements to selected panel members and supporting NRC staff. The panel will be chaired by Robert Minogue, Director, Office of Standards Development. The hearing will begin at 9:00 a.m. on Wednesday, November 21, 1979 at the Rose Herman Lehrman Arts Center Auditorium of the Harrisburg Area

Community College, 3300 Cameron Street Road, Harrisburg, Pennsylvania. The statements should address either or both of the following two subjects:

(1) Whether the TMI accident meets the criteria contained in §§ 140.84 and 140.85 of Part 140 of the Commission's regulations, and

(2) Whether uncertainties in radiation measurements taken during the accident are sufficient to warrant a finding that Criteria I in § 140.84 was satisfied.

In order to allow maximum participation, in the event that there are a large number of requests to present oral statements, the panel may have to impose a five minute time limit on the length or oral statements. The panel will accept oral summaries of longer statements to be submitted in writing. Those persons wishing to present oral statements should call NRC's Antitrust and Indemnity Group collect on or before November 19, 1979 at 301-492-8337 to have their names placed on a list of intended speakers. Written statements may be submitted to the panel at the time of the hearing or they may be mailed to the Chief, Antitrust and Indemnity Group, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555. Both oral and written statements and the transcript of the hearing, which will be made public, will be made a part of the official record of this proceeding.

Separate Views of Commissioners Ahearne and Bradford

The issue of whether TMI meets the current ENO criteria is not much of an issue. Unless the releases are much greater than all of the estimates made by various government agencies so far, TMI will not meet the criteria. Consequently, if there is to be a public hearing, Commissioners Ahearne and Bradford would have broadened the discussion to include consideration of whether the ENO criteria should be changed in light of our experience with TMI. It is likely the public will be more interested in discussing this issue and have more to say about it than whether TMI meets the current criteria. However, the other Commissioners did not agree with this addition to the scope of the hearing.

Notwithstanding the separate views expressed above, the Commission has concluded that the subjects that should be covered in statements presented in the November 21 hearing should be addressed to the two specified in the main body of this notice.

Dated at Bethesda, Maryland this 1st day of November 1979.

For the Nuclear Regulatory Commission.

Lee V. Gossick,

Executive Director for Operations.

[FR Doc. 79-34382 Filed 11-5-79; 8:45 am]

BILLING CODE 7590-01-M

[Docket No. 50-312]

Sacramento Municipal Utility District (Rancho Seco Nuclear Generation Station); Cancellation of Prehearing Conference

November 2, 1979.

Michael L. Glaser, Chairman, Dr. Richard F. Cole, Member, Frederick J. Shon, Member.

Please take notice that, due to the sudden illness of the Board Chairman, the prehearing conference scheduled in this proceeding for November 7, 1979 is cancelled until further notice.

Dated at Bethesda, Maryland, this 2nd day of November, 1979.

For The Atomic Safety And Licensing Board.

Richard F. Cole,

Member.

[FR Doc. 79-34434 Filed 11-5-79; 8:45 am]

BILLING CODE 7590-01-M

SECURITIES AND EXCHANGE COMMISSION

[File No. 81-493]

Alanthus Corp.; Notice of Application and Opportunity for Hearing

October 30, 1979.

Notice is hereby given that Alanthus Corporation ("Applicant") has filed an application pursuant to Section 12(h) of the Securities Exchange Act of 1934, as amended (the "1934 Act") for an order granting Applicant an exemption from the provisions of Sections 13 and 15(d) of the 1934 Act.

The Applicant states, in part:

1. On August 14, 1978, Applicant became wholly-owned by U.T.G., Inc. and Olympus Associates. As a result of the merger, Applicant no longer has any publicly owned common stock, and there is no longer a trading market in applicant's equity securities.

2. Applicant has three issues of debentures outstanding which are traded in the over-the-counter market, and all of these issues are held by less than 300 holders. The 6% debentures have no more than 249 holders, the 10% have 126 holders, and the 9⅞% have 180 holders.

3. The Applicant is subject to the reporting provisions of Sections 13 and 15(d) of the 1934 Act.

In the absence of an exemption, Applicant is required to file reports pursuant to Sections 13 and 15(d) of the 1934 Act and the rules and regulations thereunder for the fiscal year ended December 31, 1978 and for the fiscal year ending December 31, 1979. Applicant believes that its request for an order exempting it from the reporting provisions of Sections 13 and 15(d) of the the 1934 Act is appropriate because the Applicant believes that the time, effort and expense involved in the preparation of additional periodic reports will be disproportionate to any benefit to the public.

For a more detailed statement of the information presented, all persons are referred to the applicaton which is on file at the offices of the Commission at 1100 L Street, N.W., Washington, D.C. 20549.

Notice is further given that any interested person not later than November 26, 1979 may submit to the Commission in writing his views or any substantial facts bearing on this application or the desirability of a hearing thereon. Any such communication or request should be addressed: Secretary, Securities and Exchange Commission, 500 North Capitol Street, N.W., Washington, D.C. 20549, and should state briefly the nature of the interest of the person submitting such information or requesting the hearing, the reason for the request, and the issues of fact and law raised by the application which such person desires to controvert. At any time, after this date, an order granting the application may be issued upon request or upon the Commission's own motion.

For the Commission, by the Division of Corporation Finance, pursuant to delegated authority.

George A. Fitzsimmons,

Secretary.

[FR Doc. 79-34219 Filed 11-5-79; 8:45 am]

BILLING CODE 8010-01-M

[Rel. No. 10921; (811-1553)]

Astron Fund, Inc.; Filing of Application Pursuant to Section 8(f) of the Act for Order Declaring That Applicant has Ceased To Be an Investment Company.

October 30, 1979.

Notice is hereby given that the Astron Fund, Inc. ("Applicant") 1100 One Washington Plaza, Tacoma, Washington 98402, registered under the Investment Company Act of 1940 ("Act") as a closed-end, non-diversified, management investment company, filed

UNITED STATES
NUCLEAR REGULATORY COMMISSION
Office of Public Affairs
Washington, D.C. 20555

No. 79-196
Contact: Clare Miles
Tel. 301/492-7715

FOR IMMEDIATE RELEASE
(Mailed - November 6, 1979)

NRC TO HOLD INFORMAL HEARING NOVEMBER 21 IN HARRISBURG CONCERNING DETERMINATION ON THREE MILE ISLAND ACCIDENT

The Nuclear Regulatory Commission staff will conduct a one-day informal hearing on November 21 in Harrisburg, Pennsylvania, to hear public statements on whether the Commission should determine that the waivers of defenses provisions of the Price Anderson Act should be applied in claims involving the March 28 accident at the Three Mile Island Nuclear Power Plant in Pennsylvania. These provisions of the Price Anderson Act would come into effect if the Commission determines that the accident was an "extraordinary nuclear occurrence."

The hearing will begin at 9:00 a.m. on Wednesday, November 21, in the Rose Herman Lehrman Arts Center Auditorium of the Harrisburg Area Community College, 3300 Cameron Street Road, Harrisburg. It will be conducted by an NRC staff panel chaired by Robert Minogue, Director of the Office of Standards Development. Other panel members are Howard Shapar, Executive Legal Director; Jerome Saltzman, Chief, Antitrust & Indemnity Group; Frank Congel, Leader, Radiological Impact Section; Harold Peterson, Jr., Senior Environmental Health Physicist. A public hearing on this matter was requested by Mr. David Berger and reflects the Commission's interest in having a complete record on which to base its determination.

For a determination that the accident was an "extraordinary nuclear occurrence," (ENO), there must have been a substantial release of radioactive material offsite--either radiation doses received by individuals or radiation levels on specific areas of land, and there must have been substantial offsite damages. The Commission's regulations specify criteria that must be met in order that this determination can be made.

The statements to be presented at the hearing should address either or both of the following: (1) whether the TMI accident meets the criteria in the regulations and (2) whether uncertainties in radiation measurements taken during the accident are sufficient to warrant an affirmative finding that the criterion on radiation release has been met.

As part of the Commission's determination to hold a hearing and the subjects it wished the public to comment on, separate views were expressed by Commissioners John Ahearne and Peter Bradford. They said the issue of whether TMI meets the current ENO criteria is not much of an issue. They further stated that unless the releases are much greater than all of the estimates made by various Government agencies so far, TMI will not meet the criteria. Consequently, they would have broadened the discussion at any hearing to include consideration of whether the ENO criteria should be changed in light of the experience with TMI. They believed it is likely the public will be more interested in discussing this issue and have more to say about it than whether TMI meets the current criteria. However, the other Commissioners did not agree with this addition to the scope of the hearing.

To allow for maximum participation in the hearing, if there are a large number of requests to make oral statements, the Panel may have to impose a five minute time limit. The Panel will accept oral summaries of longer written statements. Those wishing to present oral statements should call NRC's Antitrust and Indemnity Group collect on or before November 19 at 301/492-8337 to have their names placed on a list of intended speakers. Written statements of any length may be submitted to the Panel at the time of the hearing or they may be mailed to the Chief, Antitrust and Indemnity Group, Nuclear Regulatory Commission, Washington, D.C. 20555.

#

MEETING REPORT
COMMITTEE OF AGENCY REPRESENTATIVES TO DETERMINE
THE NEED FOR FURTHER ASSESSMENT OF POPULATION DOSES
(THREE MILE ISLAND ACCIDENT)
November 28, 1979

PURPOSE

To consider the need for a reassessment of the population dose (collective and individual) resulting from the accident at the Three Mile Island Nuclear Station.

CONCLUSION

Population dose estimates prepared by several groups are reasonably consistent. No new body of data has been identified which would significantly alter those estimates. The Committee did not identify any additional assessment that it could perform which would substantially alter the previous estimates.

DISCUSSION

The Committee reviewed the available data with particular emphasis on any new data which were not included in the previous dose estimates. We concluded that there is no new body of data now available which would appreciably alter the dose estimates. The Committee also reviewed and compared the published dose estimates. The published collective and individual dose estimates based on dosimetry and environmental measurements were reasonably consistent. The principal mode of exposure to the off-site population was from external exposure to noble gases. Dose contributions to internal organs from inhaled or ingested radionuclides are a small fraction of the whole body dose.

The documents reviewed were:

1. Population Dose and Health Impact of the Accident at the Three Mile Island Nuclear Station, May 10, 1979.* This report by the Ad Hoc Population Dose Assessment Group included four collective dose estimates derived from TLD data. The estimates were 1600, 2800, 3200 and 5300 person-rem with a mean of 3300 person-rem. An additional estimate of 2600 person-rem (through March 31, 1979) was derived from TLD data and a meteorological dispersion model. The report also included an independent DOE estimate of 2000 person-rem using aerial monitoring and meteorological data. The maximum whole body dose to an off-site individual was estimated to be less than 100 mrem.

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* This report is available from the Superintendent of Documents as GPO 017-001-00408-1 or from the Nuclear Regulatory Commission as NUREG-0558.

2. Assessement of Off-Site Radiation Doses From the Three Mile Island Unit 2 Accident (TDR-TMI-116), July 31, 1979. This report, prepared by Pickard, Lowe and Garrick, Inc. for the Metropolitan Edison Company estimates the whole body collective dose to be 3500 person-rem using TLD data, an estimated source term derived from in-plant area monitors, and meteorological data. The maximum whole body dose to an off-site individual was estimated to be 76 mrem.

3. Report of the Task Group on Health Physics and Dosimetry to President's Commission on the Accident at Three Mile Island, (October 31, 1979). The most probable collective whole body dose estimate presented in the report is 2800 person-rem (2000 person-rem when corrected for shielding and occupancy). A lower estimate of 500 person-rem was presented from atmospheric dispersion models using an estimated source term from stack and area monitor data. The maximum whole body dose to an off-site individual was estimated to be between 20 and 70 mrem.

Within the range of dose estimates included in these documents, the projected number of health effects will not change significantly.

Results of calculations based solely on estimates of releases of radioactive material are considerably lower than estimates derived from environmental measurements. A large uncertainty still exists with respect to the input parameters necessary for the modeling efforts, particularly in the estimates of releases of radioactive material. Further efforts to improve predictive capabilities of this modeling may prove useful.

AGENCY PARTICIPANTS

Erich W. Bretthauer
Office of Research & Development
U. S. Environmental Protection Agency

Christopher B. Nelson
Office of Radiation Programs
U. S. Environmental Protection Agency

Harold T. Peterson, Jr.
Standards Development
U. S. Nuclear Regulatory Commission

Allan E. Smith
Office of Research & Development
U. S. Environmental Protection Agency

Robert J. Bores
Inspection & Enforcement
U. S. Nuclear Regulatory Commission

Marvin Rosenstein
Bureau of Radiological Health
Food & Drug Administration
U. S. Department of Health, Education & Welfare

Kenneth R. Baker
Operational and Environmental Safety
U. S. Department of Energy

Margaret A. Reilly
Bureau of Radiological Protection
Pennsylvania Department of Environmental Resources

APPENDIX C

PUBLIC COMMENTS

I. Individuals and Groups Commenting on ENO Determination and Comment Synopses

1. William B. Schultz - Submits a petition for rulemaking to modify ENO procedures. Available data is inconclusive and in view of the measurement gaps the Commission should weigh the health related data in favor of the safety of the public and find that TMI was an ENO. More responsive criteria are needed. Criteria were met if Congressional intent considered.

2. Gene McCrae Albright - Comments on the inadequacy of the ENO criteria. The monitoring was inadequate.

3. Robert Head - Questions the methods of calculation for determining if Criterion I was met. Additional information is needed.

4. Mrs. Lawrence Miller-References the statements of Albert Gibson and others on data measurements.

5. Cynthia Birise - Comments that criteria for making an ENO finding are unrealistic. Measurements were faulty.

6. Jameson and Milspan, attorneys - While inaccurate data makes it impossible to make an ENO determination for Criterion I, Criterion II has been met. All evacuation expenses should be included. NRC should not make a determination until after all of the technical studies are completed.

7. Michael Hershey - Incomplete data monitoring makes it impossible to determine whether ENO has occurred but believes an ENO occurred. Damages can't be assessed because of long latency period.

8. Sarah White - Nuclear power generation is too dangerous a technology to pursue. Favors an ENO determination.

9. Anna Fulginiti - It is too soon to make an ENO determination

10. Anne Hurst - It is too soon to make an ENO determination

11. Jack E. Winzenried - Criteria were not met and therefore there was no ENO.

12. D. E. Vandenburgh, Yankee Atomic Electric Company - Neither element of Criterion I, i.e., radiation exposure to offsite persons or property has been satisfied. If Criterion I is not satisfied,

therefore, it is improbable that Criterion II could be satisfied either.

13. William A. Hess - It is too soon to determine whether the TMI accident could be classified as an ENO. The ENO definition is unacceptable.

14. Lew Church - The accident was an ENO because the reactor partially melted and pregnant women and children were evacuated.

15. Frederick Brenn - Agreed that the accident was not an ENO.

16. Aubrey V. Godwin, Alabama Dept of Public Health - Criterion I has not been met. Voluntary action costs incurred by individuals should not be considered part of the damage costs for Criterion II but certain added state and local operating costs should be included.

17. Chauncey Kepford, Environmental Coalition on Nuclear Power - It is premature to make an ENO finding in view of the fact that additional emissions might be released from the plant. Criterion I is unnecessary because any accident that meets Criterion II will also meet Criterion I. The ENO criteria need to be revised. Monitoring

data should be independently evaluated by the scientific community. Calculated doses using design basis accidents would be higher than Criterion I levels.

18. Paul Makan - If Three Mile Island is not to be considered an ENO, then the criteria need to be lowered.

19. R. W. Miller, Jr. - If the TMI accident is not considered an ENO, then the economic value of Mr. Miller's residence (located in South Carolina) would be reduced.

20. Holly Lou Ann Holyk - The ENO criteria must be updated to reflect the effects (many of which will only appear over the long term) of low level radiation. Also, there was inaccurate radiation monitoring.

21. Mrs. Bruce Smith - Radiation monitoring was inaccurate. Her personal mental health was affected and the long-term effects of radiation are unknown.

22. National Assembly of Women Religious - Because inaccurate and incomplete radiation monitoring made it impossible to monitor radiation exposure, the accident should be declared an ENO. Public was inadequately informed of risk.

23. Donald E. Hossler - Based on the inaccurate monitoring and statements by Mr. A. Gibson of the NRC, the accident should be declared an ENO. Criteria should include psychological stress.

24. Lee B. Musselman, Three Mile Island Alert, Inc., - Based on statements by Thomas Gerusky of the Pennsylvania Bureau of Radiation Protection and Albert Gibson of the NRC, Iodine - 131 escaped in an unknown quantity and there could be one or more persons who received the dose necessary to trigger an ENO. Under Criterion II, there was one reaction to iodine and two psychological breakdowns that resulted in hospitalization within one month of the accident. There have also been severe economic consequences arising out of the accident. It is too early, however, to determine definitely whether the requirements of Criterion II have been met. Until the accident is over, the accident cannot be classified as an ENO.

25. Holly S. Keck, ANGRY - ENO criteria are too restrictive. Inadequate monitoring made precise measurements of radioactivity released impossible to determine. Radiation levels established in criteria are too high. It is premature in view of the decontamination work necessary at TMI to declare on ENO.

26. James White, Jr. - Both ENO criteria have been met. This belief is based in part on Albert Gibson's statements.

27. Robert Hurst, Ph.D. - Based on Albert Gibsons's statements it is possible to conclude that Criterion I has been met. Criterion II has also been met.

28. Mrs. C. Kelly Zeager - The TMI accident should be declared an ENO because of the suffering and damages borne by the residents of the area.

29. James B. Hurst - Based on Albert Gibson's statements, the TMI accident should be considered an ENO. Further, there was inadequate monitoring undertaken. Cleanup may involve significant increases of radiation released to the atmosphere. Both criteria were met.

30. Timothy Bomberger - People in the TMI area suffered mentally as a result of the accident. Evacuation expenses caused financial damage.

31. Karen Goodman - The monitoring after the accident was incomplete, and thus criteria have been met.

32. Jim Morgan - Based on Albert Gibson's statements, the population could have been exposed to higher levels of radiation than measured. There were numerous costs arising out of the accident including costs borne by local and state governments and businesses. Thus, Criterion II was met.

33. Thomas J. Halligan - The radiation monitoring after the accident was inaccurate. Numerous economic consequence losses were suffered. Thus, both criteria were met.

34. Judith Johnsrud, Environmental Coalition on Nuclear Power - Until decontamination work is completed, the accident is not over. There were clinically observed injuries and deaths arising out of the radiation releases.

35. Angelina Howard - The accident was not an ENO.

36. David Berick, Environmental Policy Institute - Radiation monitoring data was inconsistent. Only 20 dosimeters were in place around the site. While Criterion I may not have been satisfied, data monitoring was neither adequate or accurate. A future BEIR interpretation may cause Criterion I to be met. Criterion II was met.

37. Rosalie Bertell, Ph. D - The ENO criteria are unreasonable.

38. Alice Broudy - The ENO criteria are outmoded.

39. Marc L. Bernstein - Because the radiation monitoring was inadequate and inaccurate, the accident should be considered an ENO.

40. Warren Prelesnik - Because data monitoring after the accident was inadequate and inaccurate, Criterion I was met. Increased cancers may well result from the low level radiation exposure. Accident is continuing.

41. Shaw, Pittman, Potts and Trowbridge, Attorneys - Submission of a report prepared by Met Edison on offsite radiation doses arising out of the TMI accident.

42. Ellie Lohen - Radiation monitoring was inaccurate. Long-term cost effects unknown.

43. James Stapleton, Environmental Management Council, Ulster County, N.Y. -The TMI accident should be classified as an ENO.

44. K. Massie - The accident should be classified as an ENO.

45. Jessica M. Van Ullen - The TMI accident should be classified as an ENO.

46. Robert Dorman - Those responsible for the accident should assume the liability.

47. Louise Hardison - No comment on whether an ENO occurred. Alleges personal damages.

48. Dayton Mobilization for Survival - The accident should be considered an ENO.

49. David Berger, Attorney - Requests a hearing in the Harrisburg area to determine whether TMI accident was an ENO.

50, 54, & 56. Jeane J. Crumley - Because the population around TMI suffered mental stress as well as financial hardships as a result of the accident, the accident should be declared an ENO. Because the radiation monitoring during the accident was inadequate no one knows the amount of radioactivity released. The ENO criteria are inadequate.

51. National Association of Atomic Veterans - Because measurements taken during the TMI accident were inaccurate, there is no way to ascertain the exposure of the people living near TMI. Even low-level radiation exposure could produce cancers in the future. The TMI accident should be declared an ENO whether or not it meets the criteria.

52. Same as 49.

53. Larry E. Arnold, Parascience International - Based on interviews with residents around the TMI reactor, numerous health effects resulting from large radiation doses can be documented which would warrant a determination of an ENO.

55. Joann Topolski - Presents monitoring data done by Mr. Harry Hall.

57. William Albert and Alice Hossfield Hess - The TMI accident should be classified as an ENO because no one knows the amount of radiation released, where the radiation went and the impact on the population around TMI. Also, the ENO criteria are unrealistic by not accounting for possible latent cancers.

58. Statement of Congressman Robert S. Walker - Requests that the Commission in making its ENO determination consider not only damages in terms of physical injury or destruction, but also damages in terms of psychological and economic impact.

II. Comments on ENO Determination Listed By Category

I. It is premature based on limited information available to make an ENO determination.

No. of comments received - 7

Comment numbers - 6, 9, 10

17, 24, 25, 34

II. The ENO criteria are inadequate and/or unreasonable

No. of comments received - 12

Comments numbers - 1, 2, 5, 13, 17,

18, 20, 25, 37, 38, 40, 57

III. The data monitoring was incomplete and inaccurate.

No. of Comments received - 24

Comments numbers - 1, 3, 4, 5, 6, 7,

20, 21, 22, 23, 24, 25, 29, 31,

32, 33, 36, 39, 40, 42, 50, 51, 54, 57

IV. The accident should not be classified as an ENO.

No. of comments received - 5

Comment numbers - 11, 12, 15, 16, 35

V. Either based on statements by NRC officials and others or for other reasons not related to technical considerations, the accident should be considered an ENO.

No. of comments received - 17

Comment numbers - 14, 17, 22, 23,

24, 26, 27, 28, 29, 30, 32, 39, 43, 44, 45, 48, 58

VI. No specific comment on ENO.

No. of comments received - 4

Comment numbers - 8, 19, 46, 47

VII. Specific data submitted as to whether the accident should be considered an ENO.

No. of comments received - 2

Comments numbers - 41, 55

III. Panel Responses to Public Comments on ENO Determination

I. It is premature to make an ENO determination since data relating to the full impact to date of the accident will not be accumulated for many years and in fact, the accident is still going on.

Response

The ENO Panel has considered the question of recommending to the Commission that the Commission postpone determining whether the TMI accident should be considered an ENO but has decided against such a postponement.

A number of commenters suggested that because of the possibility of additional releases of radioactive materials during the decontamination of the reactor, the Commission not make an ENO determination at least until after the reactor is decontaminated. Some have also suggested that a number of years (perhaps 20 years or more because of the latent period of cancer) must elapse before the Commission can be considered to have received all the pertinent data upon which to make this determination. As stated in the Panel's report, these observations have been considered but the Panel believes that it should not recommend that the Commission postpone its ENO determination for a number of reasons. First, the Federal District Court for the Middle District of Pennsylvania which is considering the various lawsuits brought as a result of the accident has requested informally that the Commission make an ENO determination. Until such a determination is made, the court would be unable to ascertain whether the waivers of defenses would be applicable. While the court could proceed if the Commission postponed its ENO determination, all things being equal, if the Commission is able to make a determination in this area, the needs of the court and the parties before the courts should be given considerable weight. In this regard, the Commission has received a request for determination of an ENO, which if the Commission had not already initiated its procedure, would have been a petition for an ENO determination provided for in the NRC regulations.

Second, the releases of radioactive materials from the TMI accident are estimated to have been within levels typical of normal operations since mid-May 1979. Additional releases since May 9, 1979 have contributed less than 1% of the total releases. The NRC intends that doses to the general population from clean-up and recovery operations be maintained well within NRC design basis guidelines for normal operation (Appendix I to 10 CFR Part 50) and EPA standards for normal operation (40 CFR Part 190). For these reasons, the Panel does not view the accident as continuing beyond the May date.

Were there to be a substantial release of radioactive materials as a result of accidents in the clean-up or recovery operations, or as a result of a transportation accident involving the radioactive wastes removed from the TMI site, the Panel believes that these would be new incidents from the point of view of an ENO determination, and not directly attributable to the original accident. While from one point of view this conclusion would appear to be adverse to the interests of claimants with respect to the March 28 accident since it would remove the possibility of the TMI accident as it has occurred to date from ever being considered an ENO, it also has the opposite effect of providing a new level of funds for the second accident if it were to occur.

The Panel wishes to emphasize that in considering the accident to encompass the period stated above, the Panel is making this conclusion for ENO purposes only. It recognizes that in other contexts, one could conclude, as did the President's Commission on the Three Mile Island accident, that the accident is continuing.

II. The ENO criteria are inadequate and/or unreasonable.

Response

As a result of the enactment by the Congress of the waiver of defenses provisions, the Commission was required to develop criteria for the making of an ENO determination. The criteria were established in 1967 and 1968 consistent with then - current standards contained in Federal Radiation Council protective action guides. The criteria were established in the course of public rule making whereby members of the public and other interested parties had the opportunity to comment. The adequacy or reasonableness of the criteria had never been questioned after enactment of the rules in part because there had never been, before TMI, an occasion to implement the criteria.

The Commission has received a petition for rulemaking to amend its ENO criteria which was published in the Federal Register on August 28, 1979 (44 FR 43128). A few of those commenting on the accident have also stated opinions that Criterion I is unnecessary since it is difficult to postulate an accident in which Criterion II would be met without Criterion I also having been met. A thorough review of the reasonableness and adequacy of modifying the criteria based on comments received such as those discussed above as well as other information available will be undertaken. However, with respect to the TMI accident, the Panel was directed by the Commission to make explicit findings on whether the Commission's specific ENO criteria in the regulations had been met.

III. Because the data monitoring was incomplete and inaccurate the amount of nuclear material which escaped during the accident is unknown. Certain individuals were alleged to have experienced physiological effects which could only be expected from subtantial offsite radiation releases.

Response

Although effluent monitors (that is, the monitors at the stacks where the releases occurred) were "off-scale" during the initial period of the accident, estimates of the amounts of radioactive materials were made using information on the meteorological dispersion conditions and the doses measured by dosimeters already in place at the time of the accident both on and off the reactor site. These estimates made by consultants to the licensee and by the NRC staff have been published in the NRC Office of Inspection and Enforcement investigation report NUREG-0600. More recently, in the report of the Presidential Investigation Commission, that Commission stated that it was able to relate the readings on an area monitor to the noble gas effluent monitors (when they were "on-scale"). Using the area monitor readings it was possible to estimate the readings that would have been recorded by the noble gas effluent monitors had they remained "on-scale." These estimates are somewhat lower than the earlier approximate estimates. Some 762 individuals including some to whom alleged exposure to substantial radioactive iodine levels have been attributed, were given whole body counts. No activity was detected in any of these individuals which could have been associated with the TMI accident. (See memorandum Pasciak/Congel dated December 17, 1979, and memorandum Gotchy/Files dated December 19, 1979 in attached Annex.)

The initial estimates of both doses received by individuals and the total radiation exposure of the population within 50 miles of the Three Mile Island site were based upon radiation dosimeters (thermoluminescent dosimeters or TLD's) that were in place at 20 locations throughout the entire accident period. These dosimeters were part of the routine environmental monitoring program conducted by the Metropolitan Edison Company and required by the NRC. These devices integrate (sum-up) the total dose received at their locations and, therefore, provide a record of the total dose throughout the course of the accident, independent from the effluent monitors. Additional dosimeters placed by the State of Pennsylvania and by a contractor to the Nuclear Regulatory Commission were also in-place throughout the initial accident period. On March 31, 1979, the NRC placed additional TLD's at 37 locations.

Although the 20 dosimeters that were in place throughout the accident did not provide total coverage of all adjacent areas, they were situated in a manner to provide broad coverage around the plant. The Ad Hoc Interagency Group in its report in May, 1979* took the available data and made projections from the existing data into areas where data was unavailable to estimate the total population dose. Subsequent refinements of these calculations using computer models of radioactive cloud dispersion have produced population dose estimates close to the Ad Hoc Group estimates. Generally,

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* Ad Hoc Interagency Dose Assessment Group report, "Population Doses and Health Impact of the Accident at the Three Mile Island Nuclear Station," U.S. N.R.C. Report NUREG-0558, May, 1979.

these more refined estimates are lower. The agreement between the individual doses and the population doses estimated by a variety of techniques provides another indication that the doses from the accident have been fairly well estimated.

Although the thermoluminescent dosimeters (TLD's) were generally insensitive for the detection of the beta dose from noble gases, the Ad Hoc Interagency Task Group estimated the possible beta doses to the lungs, other internal organs, and to the skin.* The internal doses were only small fractions of the whole body dose. The total skin dose from gamma and beta radiation would be expected, based on estimates in the technical literature to be 2-6 times the gamma whole-body dose if it is assumed that a person is totally immersed in the radioactive gas plume without clothing or shelter for the entire period of the accident. Even under such circumstances, using this method of estimating skin dose the beta exposure of the entire population within 50-miles would not have appreciably altered the health impact estimates that the risk from skin cancer is extremely low.

Beta-emitting particulates in air were monitored by air samplers in place throughout the course of the accident as part of the routine

* Ad Hoc Interagency Dose Assessment Group report, Chapter 5.

environmental surveillance program conducted by the Metropolitan Edison Company. These samplers were supplemented by additional air samplers placed by the licensee, by NRC, by the State of Pennsylvania, and by the EPA as well as airborne samples in the DOE helicopters. With the exception of radioiodine (which is also a gamma-emitter) no significant levels of beta or alpha emitting radionuclides other than the noble gases and radiation caused by the decay of naturally occurring radon were detected.

Analysis of milk indicated that radioiodine, cesium-137, and strontium-90 were present. The cesium-137 and strontium-90 levels were not above the levels reported in pre-accident samples or in samples collected at locations remote from the TMI site as part of EPA's National Environmental Radiation Ambient Monitoring System. Therefore, it is likely that the cesium-137 and strontium-90 come from residual fallout from atmospheric nuclear testing rather than the TMI accident. The highest radioiodine levels found in milk would have produced a thyroid dose to a young child of 5 millirems. This dose is below the annual design basis thyroid dose for normal operation (15 millirems per year, see Appendix I to Part 50 of the NRC regulations) and below the EPA standards for normal operation (75 millirems per year, see EPA regulations in 40 CFR Part 190).

The NRC staff estimated that 13 million curies of radioactive material was released in the Three Mile Island Unit 2 accident (see memorandum Barrett/Distribution dated April 12, 1979 in attached Annex). One commenter using calculated doses from a design basis accident with 88,000 curies of Xe-133 released as presented, for example, in Chapter 15 of the TMI-2 Final Safety Analysis Report (FSAR), has determined by extrapolation that with average meteorological conditions the offsite doses for 13 million curies of Xe-133 released would be much higher than the measured offsite doses at TMI. In fact, he calculated doses ($\sim$ 30 rem two miles from the plant) above the 10 CFR 140.84 criterion. Partly because of this, and because of a misunderstanding of the staff's methodology, he questions the staff's method of using dosimeter readings to determine the release from TMI-2. Specifically he states that the appropriate procedure would not be to average values listed in Table 2 of the April 12, 1979 Barrett memo but to add them.

During the November 21, 1979 public hearing held in Harrisburg, Pennsylvania an NRC staff member on the hearing panel discussed with this commenter the staff's procedure for determining the accident release from the measured doses. The transcript suggests that this matter remained unresolved after the exchange. The commenter stated that the release values of Table 2 of the April 12, 1979 Barrett memo should be added for determining the total activity released rather than using the average. The averaging procedure was in fact, correctly used since the χ/Q values in Table 2 were time average values for the entire period and the dose values in the table were the cumulative doses for the entire period. The time average total release for the period was obtained based on the time averaged χ/Q and cumulative dose by dividing the cumulative dose at a specific location by the product of the time averaged χ/Q at the location times the dose factor times the duration of the release period. To determine the best estimate of the total activity released the calculated time average total releases based on the data at each specific location were then averaged. In this procedure the average of the sums (total activity released) was taken, but the procedure the commenter described employed taking the sum of the averages (activity released into a sector), which is basically the same thing and will work equally well if the data lend themselves to it. However, the commenter apparently did not recognize that the values in Table 2 were not average releases <u>into</u> a sector, but were time average <u>sums</u> of releases for the entire period; hence, the procedure that was used, average of the sums, was the appropriate one, and the one the commenter suggested was not appropriate for these data.

The process by which doses are calculated for the design basis accident consequences presented in the FSARs is usually a conservative method, if the applicant has used the staff's recommended procedures partially described in Regulatory Guide 1.3 and 1.4. The hypothetical accident of the FSAR assumes the existence of poor meteorological dispersion conditions. Analysis of the meteorological data that were obtained during the accident indicates that average dispersion conditions existed. Other parameters that must be assumed for the hypothesized accident, and which are often assumed conservatively, were actually measured at TMI. Therefore, the individual dose evaluation that is contained in Appendix E to the ENO report, as well as those presented earlier in NUREG-0558 (May 1979), are much more accurate than the FSAR calculations.

IV. The accident should not be classified as an ENO.

Response

These comments generally support the Panel's conclusion that because Criterion I was not met, the TMI accident cannot be considered an ENO.

V. Either based on statements by NRC officials and others, or for other reasons not related to technical considerations, the accident should be considered an ENO.

Response

A number of comments have been received that state that based on the acknowledged seriousness of this accident and its impact on the area and the country in general it would be absurd to say that the accident was not extraordinary. These commenters believe that if the TMI accident was not "extraordinary" then one would logically have to argue that it was "ordinary." Dictionaries define the term "extraordinary" as "going beyond what is usual, regular, or customary." Viewed in this light, the recent events at Three Mile Island are obviously extraordinary, since they would not occur during normal operations at a nuclear power plant. However, the term "extraordinary nuclear occurrence" is a term that is precisely defined by the Price-Anderson Act as follows:

> The term "extraordinary nuclear occurrence" means any event causing a discharge or dispersal of source, special nuclear, or byproduct material from its intended place of confinement

> in amounts offsite, or causing radiation levels offsite, which the Commission determines to be substantial, and which the Commission determines has resulted or probably will result in substantial damages to persons offsite or property offsite. (Atomic Energy Act (as amended), subsection 11j, 42 U.S.C. 2014j)

The definition thus provides a two-pronged test: (1) substantial offsite release or substantial offsite radiation, <u>and</u> (2) substantial offsite damages. This same section requires that the Commission "establish criteria in writing" that establishes the basis upon which the determination shall be made.

Other commenters have relied on statements made by Albert Gibson of the NRC and others which relate the problems of data measurement to the possibility of not knowing with certainty the radiation releases from TMI. It is not necessary to determine the exact releases in order to apply the ENO criteria because other sources of information can provide data for characterizing doses and contamination levels offsite. The data measurements that Gibson and others relied on in briefing the Commission on radioactive releases from TMI-2 are discussed and evaluated in the technical appendices. In particular the Panel wishes to address Mr. Gibson's statements made at Commission briefings on June 21, and August 2, 1979 which have been the subject of a number of comments. On June 21, 1979, Mr. Gibson stated that he was uncertain about the amount of radioactive material that was released to the atmosphere when the main steam atmospheric dump valves were opened for various time periods on March 28, 1979. Mr. Gibson also stated that he recalled that an inspector at the ground under the steam cloud saw levels of from 5 to 20 millirems per hour when the dump valves were opened. At the August 2, 1979 briefing, however, the following exchange takes place which modifies Mr. Gibson's earlier statements (pp 111 to 114):

> COMMISSIONER AHEARNE:
>
> But then are you saying that even if they had identified what had been the cause of the leak, as you now say, the calculations show they were outside of tech specs. Even if they had identified that and fixed it and put it back within tech specs, you still expected that the leakage would have occurred?
>
> MR. GIBSON:
>
> That's true. To discuss briefly monitoring of airborne effluents, airborne radioactivity monitors are installed in ventilation exhaust systems and in the station vent. These were off scale, as we discussed in June, because of the high radiation levels in the vicinity of the detectors. The response of these monitors provided little useful information during the period of this investigation. However, the samplers associated with these monitors were used to collect iodine and particulate samples, which were then analyzed in laboratories for a before and after assessment of what had been released from the facility. Regarding quantification of what was released from the facility, the licensee did not quantify noble gas releases until after the period of our investigation. However, because of the high degree of interest in this subject, we did put information in the report regarding the licensee's assessment of a quantity of radioactivity release.

We did not independently calculate the quantity of radioactivity released, but we did review the methodology used by the licensee and found it to be sound. And we did compare the noble gas releases to a preliminary assessment which had been made by the NRC staff with that, to be consistent.

COMMISSIONER AHEARNE:

And therefore also consistent with that ad hoc task force that looked at the measurements?

MR. GIBSON:

That is correct. I think I should say more on that point. We took the noble gas source term identified by the licensee, plugged it into a formula in 10 CFR 20 to determine compliance with 10 CFR 20, and found that the 10 CFR 20 release concentration, annual average concentration limit, was exceeded by a factor of 11.

Now this would normally imply the MPC in part 20 is generally regarded as a concentration if someone were present in that concentration continuously for seven days a week, 24 hours a day, it would produce 500 millirems per year.

Now when we came up with a factor of 11, I think a reasonable question is, does that mean a person would have received 11 times 500 millirems a year. The answer to that question is, no, it does not mean that. It doesn't mean that because of conservatism in the dose models used to derive 10 CFR 20 MPC values and because of conservatism in the atmospheric dispersion factor which we used to determine compliance with Part 20 and because no one lives at the site boundary 24 hours a day, seven days a week, without the protection of any shielding.

And when corrections are made for those conservatisms to obtain a more realistic dose, our number seems consistent with what the ad hoc committee produced. And also I would add that the ad hoc committee's estimate is based on actual doses measured by TLDs and does not take into account in its determination of doses to individuals a calculation using an atmospheric dispersion factor.

Now, our calculation is based on taking the TLD result, applying an atmospheric dispersion factor to get a source term, and

> then applying another atmospheric dispersion factor to project out to an individual. The combination of the two atmospheric dispersion factors introduces some additional uncertainty. So the bottom line is, we feel that the released quantity of noble gases is consistent with the ad hoc committee's recommendation.

The full transcripts of Mr. Gibson's remarks before the Commission on June 21 and August 2,1979 are in the Public Document Room.

VI. No specific comment on an ENO determination.

Response

These comments generally criticize the utilization of nuclear power or describe impacts of the accident in terms other than the ENO criteria. These comments did not provide any substantive data which could be technically reviewed.

VII. Specific data submitted as to whether the accident should be considered an ENO.

Response

The data supplied in this comment by attorneys for Metropolitan Edison has been considered in the reviews that resulted in the technical appendices. Data submitted by a commenter at the public hearing in Harrisburg on November 21 is analyzed in the following annex.

ANALYSIS OF RADIATION MONITORING RESULTS MADE BY MR. HARRY W. HALL AND SUBMITTED BY MRS. JOANNE TOPOLSKI

Summary

Radiation survey instrument readings were taken at several locations 5-7 miles west (WSW-WNW) of the Three Mile Island site during the period March 28, 1979 to April 17, 1979 by Harry W. Hall. Analysis of the occurrence of high count rates and concurrent wind directions indicates that these readings are generally consistent with winds blowing from the Three Mile Island site toward the measurement locations and are, therefore, indicative of radioactive materials released as a result of the accident on March 28, 1979.

The reported results are expressed in terms of counts per minute and cannot be converted to an exact exposure (dose) rate without performing a calibration of the specific instrument used for the measurements. However, an approximate conversion can be derived from these data. Typical count per minute to dose rate factor for GM survey meters would suggest a background dose rate of approximately 0.007 mR/hour or 7.0 μR/hr; equivalent to an annual exposure of about 60 mR which is not atypical of background dose rates. Using this very approximate conversion factor, the highest reported count rates (300-530 cpm) would be equivalent to 0.2 - 0.35 mR/hr. These dose rates would be significantly above normal background readings but not high enough to constitute health concern unless they persisted for long periods (a rate of 0.35 mR/hr persisting for one year would give an annual dose of approximately 3,000 mR or 3 R, whereas these readings lasted less than a few hours.) This suggests total exposures were a

few (1-10) mR which would be consistent with the approximate DOE estimates for these locations for the period March 28 - April 3rd of 1-5 mR and Ad Hoc Interagency Task Group doses estimated for the period March 28 - April 6th for locations 5 miles WNW, 5 miles W, and 5 miles WSW which were 4.2 mR, 3.4 mR, and 2.6 mR. Although the count-per-minute to exposure rate (mR/hr) conversion is only a rough estimate, it cannot be greatly in error or else the normal counting rate would indicate abnormally high background radiation dose rates. No such abnormal areas were indicated by aerial radiation measurements made in 1976.

Location of Measurement

Red Land High School is located near Interstate 83 Interchange No. 16 approximately 6-7 miles WNW of the Three Mile Island site.

Newberrytown is located approximately 4½ miles west-south-west of the Three Mile Island site.

Instrument

Although the instrument was identified as a "R.C.I. Scalar Ratemeter Model 2 306," the type of instrument used was not specified. From the fact that the results are expressed in counts per minute it was likely to be a Geiger-Mueller (GM) survey instrument.

Calibration

Results are expressed as counts per minute. Without calibration of the specific instrument used, an exact conversion from counts per minute (cpm) to milliroentgens (mR) per hour cannot be made. An approximate estimate of the dose (exposure) rate can be deduced from typical cpm to mR conversion factors for GM meters of 1500-3000 cpm = 1 mR/hr. The lower value would give a conversion factor that 1.5 cpm = 0.001 mR/hr (= 1 μR/hr). Results on March 30, 1979 indicate that count rates of 9.2 and 9.5 cpm are "below backgrounds of same area over last 13 years," whereas count rates of 10.5, 10.1, 10.6 are not indicated as being atypical for "background". Therefore one may deduce that a "typical background counting rate" was around 10 counts per minute. Using the 1.5 cpm = 0.001 mR/hr conversion factor would indicate that typical background dose (exposure) rates would be around 7 μR/hr or approximately 0.01 mR/hr which is not unreasonable for a background dose rate (approximately 60 mR/year). This value is also extremely close to the dose rates reported for these areas from 1976 aerial surveys of approximately 7.7 μR/hr as shown in Figure 1. Although the above cpm to dose (exposure) rate relationship is not exact, the above analysis indicates that it is not unreasonable. A considerably higher conversion factor from count rate to dose would result in abnormally high "background" dose rates for this area.

Statistical Variation

Measurements of radiation dose levels, even at constant dose rates, are subject to statistical fluctuations in the measurement results. The degree of variability of such results is predictable and follows a particular statistical distribution

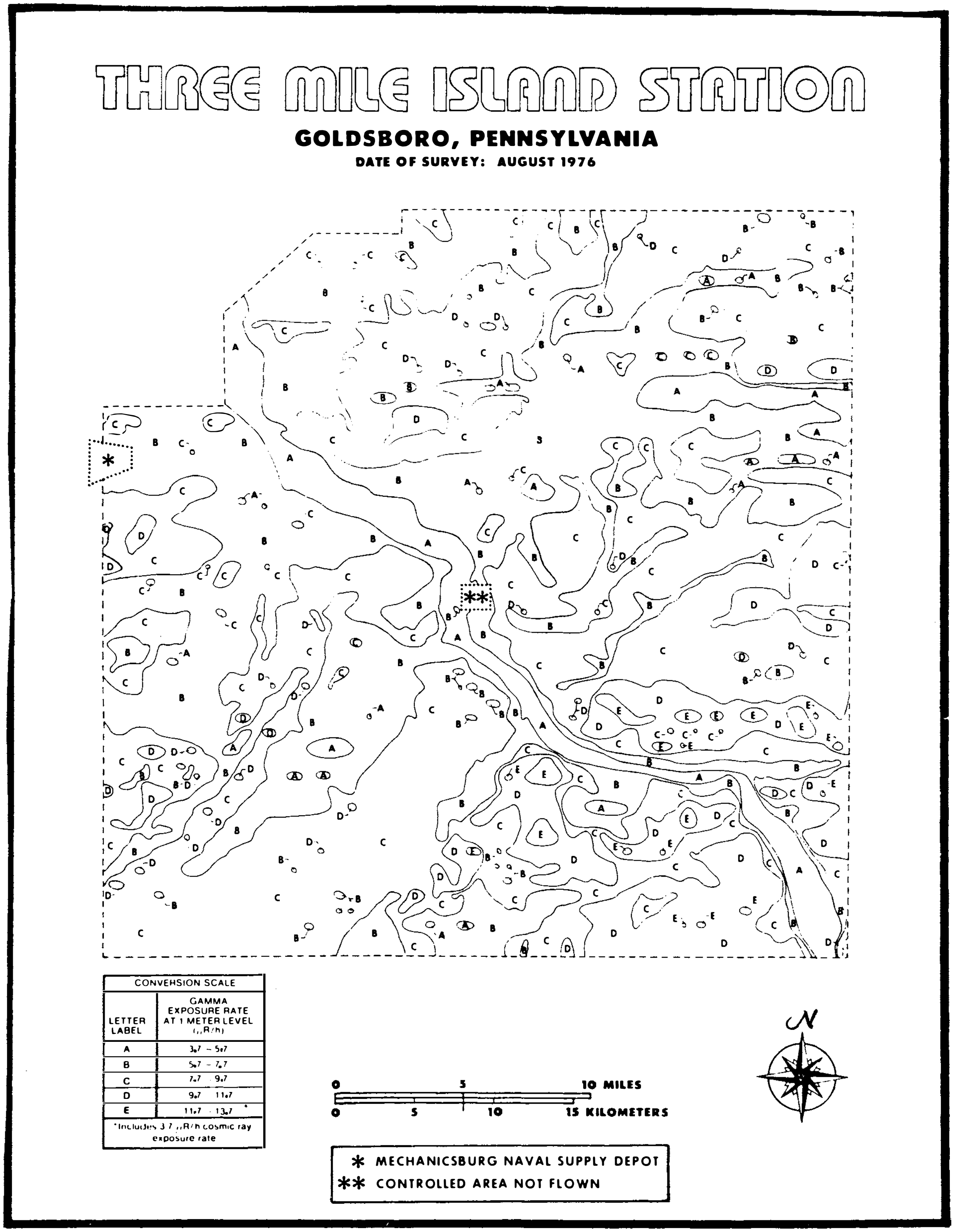


Figure 1. Radiation Dose Rates in the Vicinity of the Three Mile Island site estimated from Aerial radiation measurements made in August 1976. From A. E. Fritzsche, "An Aerial Radiological Survey of the Three Mile Island Station Nuclear Power Plant" (Goldsboro, Pennsylvania). EG&G Report EGG-1183-1710, March 1977

(the Poisson distribution) such that the estimated standard deviation* of the measurement is defined by the square root of the observed value (the square root of a given number is another number which multiplied by itself gives the given number, for example, $\sqrt{4} = 2$ as $2 \times 2 = 4$ and $\sqrt{2} = 1.414 \ldots$ as 1.414×1.414 is approximately 2). For a 10 minute measurement at an average count rate of 10 counts per minute, 100 counts would be expected to be observed. The expected standard deviation would be $(100)^{\frac{1}{2}} = 10$ counts (or 10 counts divided by 10 ten minutes = 1 count per minute). If 100 repetitive 10-minute measurements were made at a constant count rate of 10 counts per minute, approximately 95 measurements would be expected to fall within an interval from 81 counts to 122 counts (or 8.1 - 12.2 counts per minute). Values outside of this range would be expected to occur approximately in 5 cases out of 100. If the expected count rate were 12 cpm (120 counts in 10 minutes), the expected (95th percentile) range would be approximately 100 - 144 counts (10.0 - 14.4 counts per minute). Therefore, there is nothing unusual about recording 85, 92 or 110 counts (8.5, 9.2 or 11.0 counts per minute) when 100 counts (10 cpm) were expected. This is a normal consequence of the random fluctuations of radiation measurement processes and does not require unusual physical phenomena (such as an "ion field blocking mesons") to be present.

In addition to these random fluctuations, the dose rate from natural radiation also varies with time due to changes in the radiation levels. These changes

*The standard deviation is a measure of the precision of a set of measurements. A small standard deviation indicates that the individual measurements were closely grouped together. A large standard deviation indicates that the measured values were more dispersed.

result from such diverse processes as solar sun spot activity (which affects cosmic radiation intensities) and rainfall and barometric pressure (affects releases of radioactive radon gas from the soil).

ANALYSIS OF MEASUREMENTS MADE AT RED LAND HIGH SCHOOL

LOCATION IS APPROXIMATELY 6½ MILES WESTNORTHWEST OF THREE MILE ISLAND (TMI) SITE

Date	Time Period	Reported Range (Counts per Minute)	Remarks
3/28/79	3:00 pm	10.5	Wind to NNE - probable normal background reading
3/29/79	7:45 am 8:45 am 9:50 am 10:50 am 11:50 am	527 317.4 164.2 70.7 36.8	Wind from TMI to west 0700-0800 to WNW 0900, to SW 1000, to South 1100 and to NNW at 1200 Higher values are indicative of releases from TMI site as they are considerably elevated rated above apparent background levels.
3/29/79	2:00 pm	14.0	Wind at 1400 to North - No indication of TMI influence.
3/30/79	7:45 am - 12:20 pm	14.3 - 15.5	Wind during period to NNE at 0700, to South at 0800, to South-Southeast at 0900, to East-Southeast at 1000, to West at 1100, to Northeast at 1200, to Northwest at 1300 - Readings appear to be consistent with "background"

ANALYSIS OF MEASUREMENTS MADE AT NEWBERRYTOWN

(MOST MEASUREMENTS WERE PERFORMED AT THE NEWBERRYTOWN FIRE HALL)

LOCATION IS APPROXIMATELY 4½ MILES WEST-WESTSOUTHWEST OF THE THREE MILE ISLAND (TMI) SITE

Date	Time Period	Reported Range (Counts per Minute)	Remarks
8/30/79	3:00 - 3:42 pm	13.4 - 23.8	Wind from TMI to WNW area; possible radiation from plume.
	4:20, 4:43 pm	98.5, 319.8	Wind from TMI toward west; clear indication of contribution from TMI releases.
	5:05 - 12 midnight	9.2 - 13.9	Within range of background fluctuations.
3/31/79	1:00 am - 10 pm	7.8 - 14.1	Within range of background fluctuations.
4/1/79	12:30 am - 4:47 pm	7.8 - 15.9	Generally within expected background fluctuations; possible slight elevation in dose levels at 4:27-4:36 pm; wind variable to SSE at 1600 to WSW at 1700; possible indication of plume.
4/1/79	5:31 pm, 5:46 pm	48.7, 57.3	Wind to WSW at 1700 to SW at 1800; indication of plume.
	6:00 pm, 6:10 pm	15.1, 11.5	Within expected background variation.
	6:50 pm - 8:30 pm	76.0 - 342.7	Wind to SE at 1800, to west at 1900; evidence of dose contribution from TMI releases.
	9:45 pm	11.7	Within background fluctuation.
	10:05 - 11:35 pm	20.1 - 23.6	Possible slight dose contribution; wind variable WNW at 2100, 2400; NW at 2200, 2300.
4/2/79	6:45 am - 5:30 pm	8.9 - 11.5	Within expected background variation.
	6:54 - 7:18 pm	32.3 - 42.5	Wind to West-Southwest at 1800-1900; possible dose contribution from TMI.
	7:33 - 11:10 pm	14.6 - 96.2	Wind to WSW 1800-1900, to South 2000-2100, to SSW at 2200, to WSW at 2300; most values elevated above expected background dose rate; highest value consistent with wind direction from TMI site.
	7:33	(96.2)	

ANALYSIS OF MEASUREMENTS MADE AT NEWBERRYTOWN (CONTINUED)

Date	Time Period	Reported Range (Counts per Minute)	Remarks
		Measurements Made at Private Home in Newberrytown	
4/3/79	12:35 am - 9:30 pm 1:30 am	7.0 - 24.5 (24.5)	Most values within expected background variation except at 1:30 am (24.5 cpm) which is elevated slightly above background; wind at 0100-0200 is to south at 0100 and to SSW at 0200.
4/4-4/8/79	12:45 am - 4:20 pm	5.8 - 12.0	Most values within expected background variation;
4/8/79	6:58 pm	23.5	Wind from TMI toward West; value elevated slightly above expected background; possible contribution from plume
4/9/79	4:12 pm - 8:25 pm	10.7 - 11.1	Within expected background variation
4/11/79	4:10 pm	108.8	Wind from TMI toward west; evidence of TMI releases.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

DEC 1 7 1979

MEMORANDUM FOR: Frank J. Congel, Leader
Radiological Impact Section
Radiological Assessment Branch, DSE

FROM: Walt Pasciak, Radiological Impact Section
Radiological Assessment Branch, DSE

SUBJECT: TMI ACCIDENT--OFFSITE INDIVIDUALS CLAIM TO HAVING EXPERIENCED SYMPTOMS OF IODINE EXPOSURE SYNDROME

As a result of the accident at Three Mile Island Nuclear Station, several offsite residents claimed to have experienced symptoms that are characteristic of exposure to airborne concentrations of iodine greater than 1 mg/m^3. These symptoms include corrosive action on the skin, conjunctivitis, rhinitis, headache, cough, to name a few. In this memorandum, calculations are made which suggest that it is extremely improbable that residents near Three Mile Island Nuclear Station during the accident could have experienced these symptoms as a result of the iodine released from the plant. The calculations made here are based on the known threshold concentration for these symptoms, the meteorological dispersion conditions during the accident and the measured iodine release rate. The calculation that follows suggests that the release rates would have had to be much greater than those measured in order for an offsite individual to have experienced these symptoms as a result of plant iodine releases.

The rate of release of iodine from the plant that would be required for an individual to have experienced these symptoms can be calculated as follows:

$M = td/(X/Q)$ where: M = release rate of radionuclide.

td = threshold limit for these symptoms (1 mg/m^3).[1]

X/Q = meteorological dispersion factor (sec/m^3) at the individual's location.

Iodine was released during the first 43 days of the accident.[2] During this period, the largest meteorological dispersion factors that occurred were at locations close to the plant and were all smaller than 10^{-3} sec/m^3. Using a value of 10^{-3} sec/m^3 for X/Q and the td value from reference 1, the minimum release rate of iodine is estimated to be 86,400 g /day.

To compare this value to measured release rates, it must be converted to an activity release rate (Ci/day) since the actual rates were measured in this manner. This is done by multiplying M by the decay constant λ, and using the appropriate conversion factors as follows:

$$Q = \frac{(6 \times 10^{23})}{(3.7 \times 10^{10})} \frac{M\lambda}{MWt} = 1.11 \times 10^{16}\lambda \quad \text{where:}$$

Q = activity release rate (Ci/day)

M = minimum rate necessary for detection (86,400 g/day)

λ = decay constant for nuclide (sec^{-1})

MWt = molecular weight of nuclide (126 g/gram-atom)

6×10^{23} = Avogadro's number (number of atoms in a gram-atom)

3.7×10^{10} = number of disintegrations per second per curie.

The results of this equation for iodine 129, 131, 133 and 135 are summarized in the table below.

Nuclide	Q(curies/day)	Core Inventory (Ci)
I-129	14.	0.1993
I-131	$1.1 \times 10^{+10}$	6.578×10^{7}
I-133	$1.0 \times 10^{+11}$	1.497×10^{8}
I-135	$3.2 \times 10^{+11}$	1.401×10^{8}

The release rates would have to be larger than the values in this table for an individual to have experienced the symptoms. Also in the table are the estimated core inventories at the outset of the accident based on the ORIGEN code calculations.

The principal iodine releases were iodine-131 and iodine-133.[3,4] Over the entire 43 day release period about 14 curies of I-131 were released and about 2 to 3 curies of I-133 were released. These values are much smaller than those in the table. The same can be said for I-135 as the value in the table for it is enormous compared to the known release rates of the principal nuclides that were released. If small amounts of I-129 were released and not detected, their values would have been much smaller than the I-129 value in the table as the daily release rates of the principal nuclides released were smaller than the I-129 value in the table. Further, the right hand column of the above table shows that for all these nuclides the total core inventory was much less than the daily release rate. Hence, it is highly unlikely that iodine released from the Three Mile Island plant could have lead to the symptoms of the iodine exposure syndrome.

Walt Pasciak
Radiological Impact Section, RAB
Division of Site Safety and
Environmental Analysis

cc: J. Saltzman
H. Peterson

REFERENCES:

1. Plunkett, E.R., "Handbook of Industrial Toxicology," 1976, Chemical Publishers Co., Inc., New York, N.Y.

2. Memorandum from R.C. DeYoung, NRC, to W.E. Kreger, NRC, "Calculated Offsite Iodine-131 Air Concentrations from Three Mile Island," October 3, 1979.

3. Ad Hoc Interagency Dose Assessment Group, "Population Dose and the Health Impact of the Accident at Three Mile Island Nuclear Station," May, 1979, Report NUREG-0558, U.S. Nuclear Regulatory Commission.

4. Woodward, Keith, "Assessment of Offsite Radiation Doses from the Three Mile Island Unit 2 Accident," July 31, 1979, Report TDR-TMI-116, Pickard, Lowe and Garrick, Consultants.

ITED STATES
EGULATORY COMMISSION
SHINGTON, D. C. 20555

December 19, 1979

MEMORANDUM FOR: Three Mile Island Plant File

FROM: Reginald L. Gotchy, RAB, DSE, NRR

SUBJECT: FINAL RESULTS OF THE WHOLE BODY COUNTING PROGRAM FOLLOWING THE TMI-2 ACCIDENT

The total number of whole body counts was 762 which included several recounts of people with unusually high levels of naturally occurring radioactivity, and one count done on the Radiation Measurement Corporation Whole body counter located at the TMI trailer park. All other counts were done by Helgeson Nuclear Corporation (Van #4) located in Middletown except for a few people who were counted on the Helgeson system located at the island.

There was no radioactivity identified in any member of the public which could have originated in releases of radioactive materials from the TMI-2 accident. The results will be described in more detail in forthcoming NUREG-0636.

Reg

Reginald L. Gotchy
Radiological Impact Section
Radiological Assessment Branch
Division of Site Safety and
Environmental Analysis

DISTRIBUTION
Docket File 50-320
NRR Reading
RAB Reading
R. Gotchy
TMI PDR
NRC PDR

APR 1 2 1979

MEMORANDUM FOR: Distribution

FROM: Lake H. Barrett, Section Leader, Environmental Evaluation Branch, Division of Operating Reactors, ONRR

SUBJECT: PRELIMINARY ESTIMATES OF RADIOACTIVITY RELEASES FROM THREE MILE ISLAND

Attached is a summary of available information in Bethesda regarding estimates of radioactivity releases from Three Mile Island. We have estimated a total Xe-133 release of approximately 13 million curies and an I-131 release of approximately 14 curies from March 28 through April 5. This estimate was made by back calculating radioactivity releases using measured offsite TLD dose data, radioiodine air concentrations and concurrent meteorological conditions. As more information and time become available, more refined calculations can be made.

As of midday April 9, 1979, the population dose due to noble gases is estimated to be 2400 man-rems with the maximum individual exposure at less than 100 mrem (83 mrem).

Lake H. Barrett, Section Leader
Environmental Evaluation Branch
Division of Operating Reactors
Office of Nuclear Reactor Regulation

Enclosure:
As stated

SUMMARY OF PRELIMINARY RADIOACTIVITY
RELEASES FROM THREE MILE ISLAND
AS OF APRIL 7, 1979

Preliminary rough estimates of Xe-133 and I-131 releases from Three Mile Island (TMI) have been made based on reported environmental measurements made with off-site TLDs and radioiodine air samplers using meteorological data concurrent with the environmental measurement times. This approach has been used to obtain a rough estimate of releases because accurate in-plant effluent monitor information is not available at this time. The ventilation exhaust monitors did not provide accurate readings of absolute quantities of radioactivity releases during the accident because of high airborne radioactivity concentrations and direct radiation from auxiliary building components resulted in inaccurate readings, e.g., off scale.

The most feasible method for rough preliminary estimates of the amount of noble gases released during the accident is to back-calculate a curie release based on radiation measurements taken in the environs, the isotopic spectrum of the effluents and actual meteorological conditions. Environmental TLDs have been used to provide the best estimate of the integrated radiation dose at a specific location. Ground survey measurements with portable instrumentation have not been used because the actual measurement reported was for a specific short time period (~10 seconds when the measurement was taken) which is not a long enough time period to permit the calculation of meteorological dispersion conditions.

The isotopic distribution has been assumed to be essentially Xe-133 based upon ARMs data. ARMs aircraft spectrum measurements indicated mostly a Xe-133 spectrum. In the first days, some Xe-135 was detected but levels were an order of

Annex to Appendix C

magnitude below Xe-133 and quickly decayed (9 hour half-life) to undetectable levels. Consequently, we have assumed a single Xe-133 spectrum for these calculations.

Meteorological dispersion factors (χ/Q) were calculated for the specific time periods and locations of the exposed TLDs. The weather conditions for these calculations were originally based on information from the National Weather Service. Actual meteorological data from the TMI weather tower has recently been obtained by HMB and has been used with the weather service data in determining the dispersion factors for the TLD locations.

The equations and assumptions used for the calculation of the releases is provided in Table 10.

Table 1 is a summary of the Xe-133 release from TMI as a function of the time the TLDs were exposed. Tables 2 through 8 are the TLD and meteorological data used to make the estimated release for each time period. The estimated release for each time period is the average of the release calculated for each of the TLD locations. Considering the assumptions necessary to permit hand calculations, the release estimates based on each of the TLD readings are fairly consistent. The total release of Xe-133 through April 5 using this method of estimation is 13 million curies.

Lawrence Livermore Laboratory (LLL) has also provided a "very rough estimate" of the releases on April 4 based on ARMs information, which is independent of the TLD method used herein. LLL estimated the most "probable release" rate as

20 to 50 Ci/sec of Xe-133. This corresponds to 14 million to 34 million curies of Xe-133 through April 5 which is consistent with the NRC estimate of 13 million.

The iodine 131 releases have also been estimated using a similar method but with measured I-131 concentrations instead of TLD data. Eight offsite iodine sampler locations have been reported. The estimated I-131 release through April 3 is 1.4 curies. The offsite radioiodine concentrations, sampler locations, and meteorological conditions are provided in Table 9.

To date we have not received any useful information from the radioiodine inplant monitors. The radioiodine samplers should have been continuously sampling the effluents from the station vent except for the period from 0100 to 0330 on March 30 when the auxiliary building fans were secured in an attempt to reduce the release rate. When the fans were secured some unsampled building exfiltration took place, however, this was only for a short period. The iodine sampler contains a charcoal cartridge which can be removed and analyzed for radioiodines in a laboratory. Data from the inplant radiation detector which normally monitors the charcoal cartridge has not been reliable because noble gases also accumulate on the charcoal cartridge resulting in abnormally high readings. These charcoal cartridges can be counted in a laboratory within a few weeks and accurately predict what the actual I-131 release had been.

No historical information can be established from the effluent instrumentation for noble gases when the monitors are off scale. Information such as area radiation monitor readings could be useful in the future for estimating airborne concentrations, however, direct radiation from components will make this approach difficult, if not impossible.

The noble gas release history in Table 1 is generally consistent with various activities that occurred during the post-accident period. The higher release rate of the 28th and 29th probably correspond to the pumping of the contaminated water from the containment sump to the Auxiliary Building tanks which overflowed onto the Auxiliary Building floor. The noble gases then evolved from the water as it was exposed to the building air and was then exhausted by the auxiliary building ventilation system. On about 3/29 much of the water that had spilled on the floor had been pumped into tanks which reduced the evolution of gases to the air. The release rate after 3/29 and before 3/31 was reduced possibly because the letdown flow path of primary coolant was to the Reactor Coolant Bleed Holdup tanks and waste gas system. The increase in release on 3/31 could correspond to the establishment of the normal letdown path through the Makeup Tank. Establishment of normal letdown resulted in several gaseous releases as problems were encountered with leakage of dissolved gases evolving from the makeup tank vent. Also, during this period the bubble in the reactor vessel was the main concern and efforts were directed toward degasification of the primary system. The method of degasification was through the makeup tank to the vent gas system and waste gas decay tanks as well as venting the pressurizer to containment. During this mode of operation there were apparent leaks in the vent gas system between the makeup tank and waste gas decay tanks. Although little verified information concerning waste gas decay tank pressures exist at this time, it appears that the waste gas decay tank pressures did not increase as much as was expected, also indicating vent gas system leakage. The degasification of the primary system through the makeup tank could well have removed much more than 10% of the noble gases from the primary system. The initial core inventory of xenon at 0400 on 3/28 was 140 million curies. It is possible when considering the amount of Xe-133 available to be released to the primary coolant, the severe core overheating, the method of primary system degasification and the leaks in the vent gas system between the makeup tank and waste gas decay tanks that the release of 13 million curies of Xe-133 is feasible.

It is again stated that these quantitative estimates have been based on data reported from the TMI site. Much of the information was provided verbally from the site and cannot be verified at this time. As more information becomes available, more accurate estimates can be made.

TABLE 1

Preliminary Estimate of Noble Gas Releases (Xe-133)

Time Period	Noble Gas Release (Curies Xe-133)
3/28 - 3/29	4.2×10^6
3/29 - 3/31	2.2×10^6 (2 days)
3/31 - 4/1	2.1×10^6
4/1 - 4/2	0.4×10^6
4/2 - 4/3	1.1×10^6
4/3 - 4/4	0.07×10^6
4/4 - 4/5	0.2×10^6
Total	$\sim 13.0 \times 10^6$

0400 2/28 Core Inventory Xe-133 140×10^6 curies

TABLE 2

Noble Gas Release Estimates

Time Period 3/28 - 3/29 (1500 hours) (35 hr period)

TLD Location (Miles)	TLD Location (Direction)	TLD Dose* (mrem)	χ/Q (sec/m^3)	Calculated Release (Ci Xe-133)
0.4	NW	82	5×10^{-6}	3.5×10^{6}
0.7	NE	31	1×10^{-5}	6.6×10^{5}
15	SE	4.2	1×10^{-7}	9.0×10^{6}
9	SE	2	1×10^{-7}	4.3×10^{6}
2.3	SE	3	(2×10^{-7})	3.2×10^{6}
0.5	ENE	5	1×10^{-6}	1.1×10^{6}
1.6	WSW	4	2×10^{-6}	4.3×10^{5}
2.6	N	7	1×10^{-6}	1.5×10^{6}
13	S	3.3	5×10^{-8}	1.4×10^{7}
			AVERAGE	4.2×10^{6}

* Background corrected.

TABLE 3

Noble Gas Release Estimates

Time Period 3/29 (1500 hrs) - 3/31 (1000 hrs) (43 hr period)

TLD Location (Miles)	TLD Location (Direction)	TLD Dose (mrem)	χ/Q (s/m^3)	Calculated Release (Ci Xe-133)
2.3	SSE	9.3	2×10^{-6}	1.0×10^6
13	S	1.7	2×10^{-7}	1.8×10^6
15	NW	2.1	8×10^{-8}	5.6×10^6
15	SE	1.7	1×10^{-7}	3.6×10^6
2.6	N	2.9	1×10^{-6}	6.2×10^5
9	SE	1.2	2×10^{-7}	1.3×10^6
10	ENE	1.3	2×10^{-7}	1.4×10^6
			Avg.	2.2×10^6

TABLE 4

Noble Gas Release Estimates

Time Period 3/31 - 4/1 (22 hr. period)

TLD Location (Miles)	TLD Location (Direction)	TLD Dose (mrem)	χ/Q (s/m^3)	Calculated Release (Ci Xe-133)
0.5	ENE	25	1×10^{-6}	5.4×10^{6}
0.8	NE	7	6×10^{-7}	2.5×10^{6}
13.8	NW	4.6	1×10^{-7}	9.8×10^{6}
9.6	NW	5.5	2×10^{-7}	5.8×10^{6}
1.5	W	3	2×10^{-6}	3.2×10^{5}
7.0	SE	2.5	4×10^{-7}	1.3×10^{6}
4.2	SE	3.0	9×10^{-7}	7.1×10^{5}
2.9	W	1.1	1×10^{-6}	2.4×10^{5}
7.1	W	1.2	5×10^{-7}	5.1×10^{5}
5.3	W	1.0	1×10^{-6}	2.2×10^{5}
2.5	S	1.6	2×10^{-6}	1.7×10^{5}
6.2	S	1.0	7×10^{-7}	1.1×10^{5}
3.4	NE	1.6	3×10^{-6}	4.5×10^{5}
7.6	NE	2.1	1×10^{-6}	4.5×10^{5}
			Avg.	2.1×10^{6}

TABLE 5

Noble Gas Release Estimates

Time Period 4/1 - 4/2 (24 hr. period)

TLD Location (Miles)	TLD Location (Direction)	TLD Dose* (mrem)	χ/Q (s/m^3)	Calculated Release (Ci Xe-133)
2.6	303°	1.5	1×10^{-6}	3.2×10^{5}
1.3	263°	1.0	$1. \times 10^{-6}$	2.1×10^{5}
7.8	297°	0.6	4.0×10^{-7}	3.2×10^{5}
1.8	200°	0.6	6.0×10^{-7}	2.1×10^{5}
9.3	223°	0.3	6.0×10^{-8}	1.1×10^{6}
			Avg.	4.3×10^{5}

*Corrected for Background (0.19 mrem/day)

TABLE 6

Noble Gas Release Estimates

Time Period 4/2 - 4/3

TLD Location (Miles)	TLD Location (Direction°)	TLD Dose* (mrem)	χ/Q (s/m^3)	Calculated Release (Ci Xe-133)
7.8	297	0.4	2×10^{-8}	4.3×10^{6}
1.3	263	1.2	3×10^{-7}	8.6×10^{5}
1.8	200	1.0	1×10^{-6}	2.1×10^{5}
5.1	272	0.5	5×10^{-7}	1.1×10^{6}
2.4	203	1.1	5×10^{-7}	4.7×10^{5}
2.5	169	2.0	2×10^{-6}	2.1×10^{5}
6.2	178	1.3	2×10^{-7}	1.4×10^{6}
8	181	1.3	3×10^{-7}	9.3×10^{5}
7	225	0.6	1×10^{-7}	1.3×10^{6}
9.3	225	0.6	6×10^{-8}	2.1×10^{6}
12	184	1.2	1×10^{-7}	2.6×10^{6}
1.9	162	4.2	2×10^{-6}	4.5×10^{5}
1.0	151	8.9	5×10^{-6}	3.8×10^{5}

TABLE 6 (Continued)

Noble Gas Release Estimates

Time Period 4/2 - 4/3

TLD Location (Miles)	TLD Location (Direction°)	TLD Dose* (mrem)	χ/Q (s/m^3)	Calculated Release (Ci Xe-133)
5.3	310	0.4	$6. \times 10^{-8}$	1.4×10^{6}
2.6	303	1.1	$2. \times 10^{-7}$	1.2×10^{6}
1.3	252	0.8	$2. \times 10^{-6}$	8.6×10^{4}
2.9	270	0.6	$1. \times 10^{-6}$	1.2×10^{5}
7.1	262	0.7	7×10^{-7}	1.5×10^{5}
				Avg. 1.1×10^{6}

* Corrected for Background (0.19 mrem/day)

TABLE 7

Noble Gas Release Estimates

Time Period 4/3-4/4

TLD Location (Miles)	TLD Location (Direction°)	TLD Dose* (mrem)	χ/Q (s/m^3)	Calculated Release (Ci Xe-133)
1.0	151	0.24	4×10^{-6}	1.28×10^{4}
1.9	162	0.68	3×10^{-6}	4.85×10^{4}
2.5	169	0.91	2×10^{-6}	9.73×10^{4}
6.2	178	0.33	2×10^{-6}	3.53×10^{4}
8.0	181	0.28	1×10^{-6}	5.99×10^{4}
12.0	184	0.14	1×10^{-6}	3.00×10^{4}
1.8	200	0.91	4×10^{-6}	4.87×10^{4}
2.4	203	0.18	2×10^{-6}	1.93×10^{4}
7.0	225	0.46	1×10^{-6}	9.84×10^{4}
9.3	225	0.43	1×10^{-6}	9.20×10^{4}
1.3	263	1.51	2×10^{-6}	1.62×10^{5}
1.3	252	0.43	4×10^{-6}	2.30×10^{4}
2.9	270	0.91	2×10^{-6}	1.30×10^{5}
5.1	272	0.23	1.0×10^{-6}	4.92×10^{4}

TABLE 7 (Continued)

Noble Gas Release Estimates

Time Period 4/3-4/4

TLD Location (Miles)	TLD Location (Direction°)	TLD Dose* (mrem)	χ/Q (s/m^3)	Calculated Release (Ci Xe-133)
7.1	262	0.46	1.0×10^{-6}	9.84×10^{4}
2.6	303	0.11	2×10^{-6}	1.18×10^{4}
5.3	310	0.21	1×10^{-6}	4.49×10^{4}
7.8	297	0.21	4×10^{-7}	1.12×10^{5}
			Avg.	6.5×10^{4}

*Corrected for Background (0.19 mrem/day)

TABLE 8

Noble Gas Release Estimates

Time Period 4/4 to 4/5

TLD Location (Miles	(Direction°)	TLD Dose* (mrem)	χ/Q (s/m^3)	Calculated Release (Ci Xe-133)
1.0	151	0.73	6×10^{-7}	2.60×10^{5}
1.9	162	0.19	4×10^{-7}	1.02×10^{5}
2.5	169	0.18	1×10^{-7}	3.85×10^{5}
6.2	178	0.13	7×10^{-8}	3.97×10^{5}
8.0	181	0.21	6×10^{-8}	7.49×10^{5}
12.0	184	0.26	5×10^{-8}	1.11×10^{6}
1.8	200	0.18	1×10^{-6}	3.85×10^{4}
2.4	203	0.11	6×10^{-7}	3.92×10^{4}
7.0	225	0.26	3×10^{-7}	1.85×10^{5}
9.3	225	0.26	3×10^{-7}	1.85×10^{5}
1.3	263	1.11	4×10^{-6}	5.94×10^{4}
1.3	252	0.53	2×10^{-6}	5.67×10^{4}
2.9	270	0.23	3×10^{-6}	1.64×10^{4}
5.1	272	0.26	2×10^{-6}	2.78×10^{4}

TABLE 8 (Continued)

Noble Gas Release Estimates

Time Period 4/4 to 4/5

TLD Location (Miles)	TLD Location (Direction°)	TLD Dose* (mrem)	χ/Q (s/m^3)	Calculated Release (Ci Xe-133)
7.1	262	0.41	2×10^{-6}	5.85×10^{4}
2.6	303	0.19	1.0×10^{-6}	4.07×10^{4}
5.3	310	0.14	9.0×10^{-7}	3.33×10^{4}
7.8	297	0.19	2.0×10^{-7}	2.03×10^{5}
			Avg.	2.2×10^{5}

* Corrected for Background (0.19 mrem/day)

TABLE 9

Radioiodine Release Estimates
Updated 4/10/79

Time Period 3/28-3/29

Location Miles	Location Direction	Air Concentration pCi/m^3	χ/Q sec/m^3	Calculated Release Ci
0.4	N	0.47	2×10^{-5}	2×10^{-3}
2.3	SSE	<0.2	4×10^{-7}	$<4.3 \times 10^{-2}$
0.4	E	<0.02	6×10^{-7}	$<2.9 \times 10^{-3}$
15	NW	<0.03	1×10^{-7}	$<2.6 \times 10^{-2}$
9	SE	<0.04	1×10^{-7}	$<3.5 \times 10^{-2}$
2.6	N	0.08	4×10^{-7}	1.7×10^{-2}
1.6	WSW	<0.3	2×10^{-6}	$<1.3 \times 10^{-2}$
13	S	<0.02	$<1 \times 10^{-8}$	$<4.3 \times 10^{-2}$
			Avg.	$<2.3 \times 10^{-2}$

Time Period 3/29-3/31

0.4	N	22.6	2×10^{-5}	0.20
2.3	SSE	22.1	2×10^{-6}	1.91
0.4	E	20.3	1×10^{-5}	0.35
15	NW	1.8	8×10^{-8}	3.9
9	SE	0.27	2×10^{-7}	0.23

TABLE 9 (Continued)

Radioiodine Release Estimates

2.6	N	12.7	2×10^{-6}	1.1
1.6	WSW	23.9	3×10^{-6}	1.38
13	S	0.14	2×10^{-7}	0.12
			Avg.	1.2

Time Period 3/31-4/3

0.4	N	0.11	2×10^{-5}	1.4×10^{-3}
2.3	SSE	1.39	2×10^{-6}	0.18
0.4	E	0.27	2×10^{-5}	3.5×10^{-3}
9	SE	0.16	3×10^{-7}	0.14
2.6	N	0.051	5×10^{-7}	2.6×10^{-2}
1.6	WSW	0.07	2×10^{-6}	9.1×10^{-3}
13	S	0.36	1×10^{-7}	0.93
15	NW	0.024	1×10^{-7}	6.2×10^{-2}
			Avg.	0.17

Time Period 3/28-4/3 Cumulative Avg. ~ 1.4 Ci

Equation for Back Calculating Xe-133 Releases

$$N\ (\text{Ci Xe-133}) = C[\chi/Q\ \text{sec/m}^3]^{-1}\ [2.94 \times 10^{-7}\ \frac{\text{rem-M}^3}{\text{pCi-yr}}]\ [\frac{10^{12}\ \text{pCi}}{\text{Ci}}\ \frac{1\text{yr}}{3.15 \times 10^7\ \text{sec}}]\ D\ \text{rem}$$

$$N\ (\text{Ci Xe-133}) = 0.214\ (\text{TLD Dose mrem})\ (\frac{1}{\chi/Q\ \text{sec/m}^3})$$

where $C = [\text{Finite Plume Correction}]^{-1} = 2$

Reg. Guide 1.109 dose conversion of $2.94 \times 10^{-7}\ [\frac{\text{rem-m}^3}{\text{pCi-yr}}]$

Equation for Back Calculating I-131 Releases

$$N\ (\text{ci I-131}) = K[\chi/Q]^{-1}\ t\ c$$

$$N\ (\text{ci I-131}) = 3.6 \times 10^{-9}\ [\chi/Q]^{-1}\ [t\ \text{hrs}]\ c$$

where c = I-131 concentration pci/m^3

t = Time period (hrs)

$k = 3.6 \times 10^{-9}$ (sec/hr)(Ci/pCi)

APPENDIX D

STUDIES ON DOSE ASSESSMENT
AND ENVIRONMENTAL MONITORING
DATA COLLECTION CONSIDERED
BY PANEL*

* NOTE: All data provided in written and oral comments by members of the public and other interested parties were also considered and reviewed,although these data sources are not included in the listing below.

a. The report of the Ad Hoc Interagency Dose Assessment Group, "Population Dose and Health Impact of the Accident at the Three Mile Island Nuclear Station" (NUREG-0558) May, 1979

b. The "Investigation Into the March 28, 1979 Three Mile Island Accident by Office of Inspection and Enforcement" (NUREG-0600), August, 1979

c. An internal staff review being conducted for the NRC/TMI Investigation Group (Rogovin Investigation). (Ongoing)

d. A review of GPU/Met Ed data on atmospheric and liquid discharges being conducted by Porter-Goertz Consultants, Inc. (Monthly Update)

e. Report of the President's Commission on the Accident at Three Mile Island, "The Need for Change - The Legacy of TMI," October, 1979

f. "Report of the Task Group on Health Physics and Dosimetry" to the President's Commission on the Accident at Three Mile Island, October, 1979

g. "Report of the Task Group on Radiation Health Effects" to the President"s Commission on the Accident at Three Mile Island, October, 1979

h. A study and series of reports of data collected and analyses made by DOE contractors, evaluated by EG&G as the DOE Contractor, including:

   i. EG&E report of Aerial Radioactivity Monitoring System (ARMS) data.]

   ii. Lawrence Livermore Laboratory report on Atmospheric Release Advisory Capability (ARAC) study

   iii. Report from the Environmental Measurements Laboratory (New York)

i. Studies being conducted by Arthur Upton of the National Cancer Institute for the Frederickson interagency Committee on Biological Effects of Ionizing Radiation (NIH). (Report of subcommitee has been completed).

J. A report to the Atomic Industrial Forum from Roessler, Roessler & Bolch, May 18, 1979.

k. Possible additional assessments of data collected by the Bureau of Radiological Health, Food and Drug Administration, HEW.

l. State of Pennsylvania continuing program of analysis of milk, water, air, particulates and iodine and ambiant gamma. (Data will be in EPA report)

m. Collins, John, William Travers, Ron Bellamy, "Report on Preliminary Radioactive Airborne Releases and Charcoal Efficiency Data: Three Mile Island Unit 2," United States Nuclear Regulatory Commission.

n. Memorandum for R. C. DeYoung, NRC, to W. Kreger, NRC, "Calculated Offsite Iodine-131 Air Concentrations from Three Mile Island," October 3, 1979.

o. Kreger, W. E. memorandum for Richard C. DeYoung, "Calulated Offsite I-131 Air Concentrations for the Three Mile Island Area Locations," dated October 25, 1979.

p. Pasciak, Walt, Frank J. Congel, Edward F. Branagan, Jr., "Releases of Radionuclides into the Susquehanna River from Three Mile Island Nuclear Station during the Period of 3/28/79-5/11/79 - Data and Analysis," September 1979, Draft Report NUREG-0598, Radiological Assessment Branch, U. S. Nuclear Regulatory Commission, Washington, DC.

q. Pasciak, W., E. F. Branagan, Jr., F. J. Congel, J. Fairobent, "A Method for Calculating Doses to the Population from Xe-133 Releases during the Three Mile Island Accident," Draft, September 1979, Radiological Assessment Branch, U. S. Nuclear Regulatory Commission.

r. Woodard, Keith, "Assessment of Offsite Radiation Doses from the Three Mile Island Unit 2 Accident," July 31, 1979, Report TDR-TMI-116, Pickard, Lowe, and Garrick Consultants.

APPENDIX E

AN ASSESSMENT OF THE RELEASES OF RADIONUCLIDES FROM THE ACCIDENT AT THREE MILE ISLAND FOR MEETING THE CRITERION OF 10 CFR 140.84

December, 1979

Division of Site Safety and
Environmental Analysis

Office of Nuclear Reactor Regulation

NRC

SUMMARY

10 CFR Part 140, Subpart E, sets forth the procedures the Commission will follow and the criteria the Commission will apply in making a determination as to whether there has been an extraordinary nuclear occurrence as a result of unintentional releases of radioactive materials to the environment from a nuclear facility. This appendix provides calculations related to this determination for the releases that were made as a result of the Three Mile Island accident.

In Appendix E calculations of doses to individuals are made for releases of iodine 131 and noble gases to the atmosphere. Calculations are also made for ground contamination and for releases to the aquatic environment. In making estimates of doses due to the iodine and noble gas releases to the atmosphere, several hypothetical situations were assumed. These calculations placed individuals at locations near the plant where the dose would be highest and for a period of time extending throughout the duration of the releases. The results of all of these calculations were below the levels of 10 CFR 140.84 for all hypothetical cases. In several of the calculations that were made, assumptions were employed to ensure that the results represented upper bound estimates. These assumptions are as follows: (1) the use of a source term that was several times larger than the best estimate of releases that actually occurred, (2) no credit taken for any additional decay of radionuclides over time after release from the facility, and (3) meteorological models based on assumptions that tend to underestimate actual dispersion (described in text). The calculations

regarding releases to the aquatic environment resulted in very small estimates of dose, as expected, since the releases were within technical specification requirements. Thus, the liquid radionuclide pathways resulted in doses which were a small fraction of the levels stated in 10 CFR 140.84. Several estimates of ground contamination were made for locations off the Three Mile Island site using the same hypothetical assumptions as used in the dose calculations. The ground contamination values were also below the levels of 10 CFR 140.84.

Calculations of doses due to the noble gas releases for hypothetical and real individuals offsite who received the highest exposure have been made by several groups. The results of three of these groups are presented in the attached appendix with a brief description of their methods. All studies consistently conclude that the maximum offsite dose at the likely location of a real individual is less than 100 mrem. Nevertheless, the possibility was examined that an offsite individual may have been closer to the plant than was the person whose dose was determined in the analyses mentioned above. A hypothetical situation was constructed whereby an individual was assumed to be located in a boat along the perimeter of the island for the entire course of the releases of noble gases. Furthermore, in order to establish the maximum dose such a hypothetical individual could receive, it was assumed that the individual moved the boat as the wind shifted so that it was always downwind of the plant in the radioactive plume. This scenario resulted in a dose of 2.3 rem total body and 4.7 rem skin. Both of these dose values are well under the level of 10 CFR 140.84.

Estimates of inhalation dose from I-131 for the nearby populated area was based on the 43 days of releases which occurred during the accident. The calculated dose was 19 mrem to the thyroid of a child. This calculation was for locations offsite where individuals would be expected to be located and the dose was expected to be highest. To take into consideration the possibility that an individual might have been located closer to the plant, calculations were done for several hypothetical individuals. One calculation was based on the assumption that the individual was located on the exclusion boundary in the sector where the dose would be highest for the entire 43 days (24 hours per day) of the releases. Another calculation was for the nearest shorelines to which the public has access. It was assumed that the hypothetical individual was there for the entire 43 day release period and was located where the dose would be expected to be highest. Finally, another calculation was based on the assumption that a hypothetical individual was located on the exclusion boundary for the entire 43 day period and moved around it in such a way to be located always downwind of the plant similar to the noble gas calculations noted above. Upper bound estimates of the source term and the meteorological dispersion parameters that were previously mentioned were used in these hypothetical calculations. The dose results of all of these approaches were below the level of 10 CFR 140.84.

A. INTRODUCTION

This report relates to Criterion I (10 CFR 140.84) for determination of an extraordinary nuclear occurrence pursuant to 10 CFR 140 Subpart E. Briefly, the criterion requires that the Commission determine that there has been a substantial discharge or dispersal of radioactive material offsite, or that there have been substantial levels of radiation offsite, when, as a result of an event comprised of one or more related happenings, radioactive material is released from its intended place of confinement or radiation levels occur offsite and one of the following findings are also made: (1) One or more persons offsite were, could have been, or might be exposed to radiation or to radioactive materials resulting in a dose or in a projected dose in excess of levels in the following table:

Table 1

Total Projected Radiation Doses

Critical Organ	Dose (rems)
Thyroid	30
Whole Body	20
Bone Marrow	20
Skin	60
Other Organs and Tissues	30

(2) Surface contamination of at least a total of any 100 square meters of offsite property has occurred and such contamination is characterized by levels of radiation in excess of one of the values listed in columns 1 or 2 of Table 2.

Table 2

Total Surface Contamination Above Background

Type of emitter	Offsite property contiguous* to site (of persons with whom an indemnity agreement is executed)	Other offsite Property
α emission from transuranic isotopes	3.5 μCi/m^2	0.35 μCi/m^2
α emission from other isotopes	35. μCi/m^2	3.5 μCi/m^2
β or γ emitters	40. mrad/hr @ 1 cm.**	4. mrad/hr @ 1 cm.**

*This column applies to areas on Three Mile Island outside the fence. For all other property, exclusive of Three Mile Island, the right column applies.[16]

**Not more than 7 mg/cm^2 of absorber between contaminated plane and point of measurement.

This report is organized in the following manner. The first section (B. GASEOUS RELEASES) describes releases made to the atmosphere and calculations of the resulting doses. It is subdivided into sections on noble gas releases and iodine releases. Only these two types of radioactive material are dealt with for gaseous releases because they represent essentially all of the activity released.[1,3] Addition of other isotopes would have only a miniscule effect in comparison to these for determination of both dose and ground contamination. The second section (C. AQUATIC RELEASES) of this report describes calculations of the dose due to the aquatic releases. Aquatic discharges were within current standards for normal operation[20] and contribute very little dose to persons offsite. The actual calculations from the aquatic releases are not made here but are based on a previous analysis.[10] The final section of this report discusses the results of the calculations in the context of Criteria-I.

A word about the approach in making calculations is appropriate here. Two types of estimates are calculated. The first type involves assumptions which are designed to define a best estimate of the actual maximum doses that may have occurred. The results of these calculations generally confirm calculations made in previous studies, or in some cases, previous studies are cited as best estimates and calculations are not made here. The second type of calculation employs parameters and assumptions of human behavior scenarios which are purposely chosen to establish upper bounds on the best estimate calculations.

B. GASEOUS RELEASES

I. Noble Gases

a) Introduction

There are three analyses of offsite doses due to the releases of noble gases upon which dose calculations made here are based. The first was done by the Department of Energy (DOE) and is contained in the Ad Hoc Interagency Dose Assessment Group Report[1], the second is a draft paper prepared by the NRC Radiological Assessment Branch (RAB) staff for publication in the open scientific literature[2], and the third is an assessment done by Dr. Keith Woodard of Pickard, Lowe, and Garrick, consultants to Metropolitan Edison Company.[3] The three reports represent the major work done in this area, except for the work that was done for the President's (Kemeny) Commission on the accident at TMI. The results of the

Kemeny Commission report are consistent with the three reports used here. The three approaches are presented here in order to demonstrate the level of certainty to which the calculation made here are based.

The majority of the noble gas releases were made during the first few days of the accident, and contributions beyond the first week (or even the first few days) do not result in significant dose.[1,2,3] The three reports that are discussed here analyze data collected over different periods, hence, some differences are expected, but they all include data from the period when the releases were highest. However,the differences in results should be insignificant as far as the 10 CFR 140.84 criterion is concerned. The time period over which the DOE helicopter flights were made (presented in Reference 1) was March 28 through April 10. The time period over which the RAB Staff analysis (presented in Reference 2) applies for was March 28 through March 31. Finally, the time period over which the Pickard, Lowe, and Garrick report (presented in Reference 3) applies for was March 28 through April 6. The latter analysis covers the entire period of releases.

To estimate the dose an individual offsite could have been exposed to involves estimating the dose distribution around the site and devising scenarios which characterize individual location behavior over the release period. The approach that is used here is two-fold. The first is one where best estimates are made and the second is one where a scenario is hypothesized which is selected to calculate the dose a hypothetical individual would have received who might have managed to stay very close to the plant during the releases where the dose would be expected to be highest. The spatial dose distribution that is used here is selected on conservative grounds.

b) Spatial Dose Distribution

1. Interagency Report[1]

Several different methods were used in this report to calculate the dose to the population due to the Xe-133 releases. However, only one method was used for calculating the spatially dependent dose distribution. The method is described in detail in Appendix A of the interagency report.[1] The method that was used was developed by the Department of Energy (DOE) and was based principally on the average measurements of the radiation exposure rates in the plume made during over 200 helicopter flights, which began early on March 28 and continued through April 10, supplemented by meteorological information collected at the plant. Geiger-Mueller survey instruments with probes having open, low density windows, to enable measurements of the γ radiation exposure, and high energy β exposure were used. The helicopter was maneuvered to find the maximum radiation exposure rate.

Figure 1 was taken from Appendix A of the Interagency Report. The figure shows the accumulated exposure profile in units of mR for the 0-2 mile radius (note that for γ or β radiation a dose of 1R is equivalent to a dose of 1 rem (10 CFR 20.4)). It is in this region the maximum exposed individual is expected to be found. The figure indicates that there are three lobes where the cumulative radiation levels were highest. These are toward the NNW, SSE and ENE directions. The exposure profiles were generated from direct readings off Geiger-Mueller survey instruments which were calibrated with the 660 keV peak of Cs-137. Since the Xe-133 peak is about 81 keV, the readings must be corrected for this lower energy. The calibration curves for these instruments indicate an over response to the Xe-133 peak by about a factor of 3, hence, these profiles should be decreased by about that much.

2. Radiological Assessment Branch Staff Analysis[2]

In the assessment done by the NRC Radiological Assessment Branch staff,[2] the dose distribution was calculated based on meteorological predictions (supplied by the NRC Hydrology-Meteorology Branch) based on a Gaussian straight-line dispersion model as described in NRC Regulatory Guide 1.111[4], and on measurements of accumulated dose on thermoluminescent dosimeters (TLD) around the site. The results of this assessment are presented here and in the interagency report.[1] The assessment handles the radiation exposure for two time periods separately, the first one being March 28, 4 a.m.

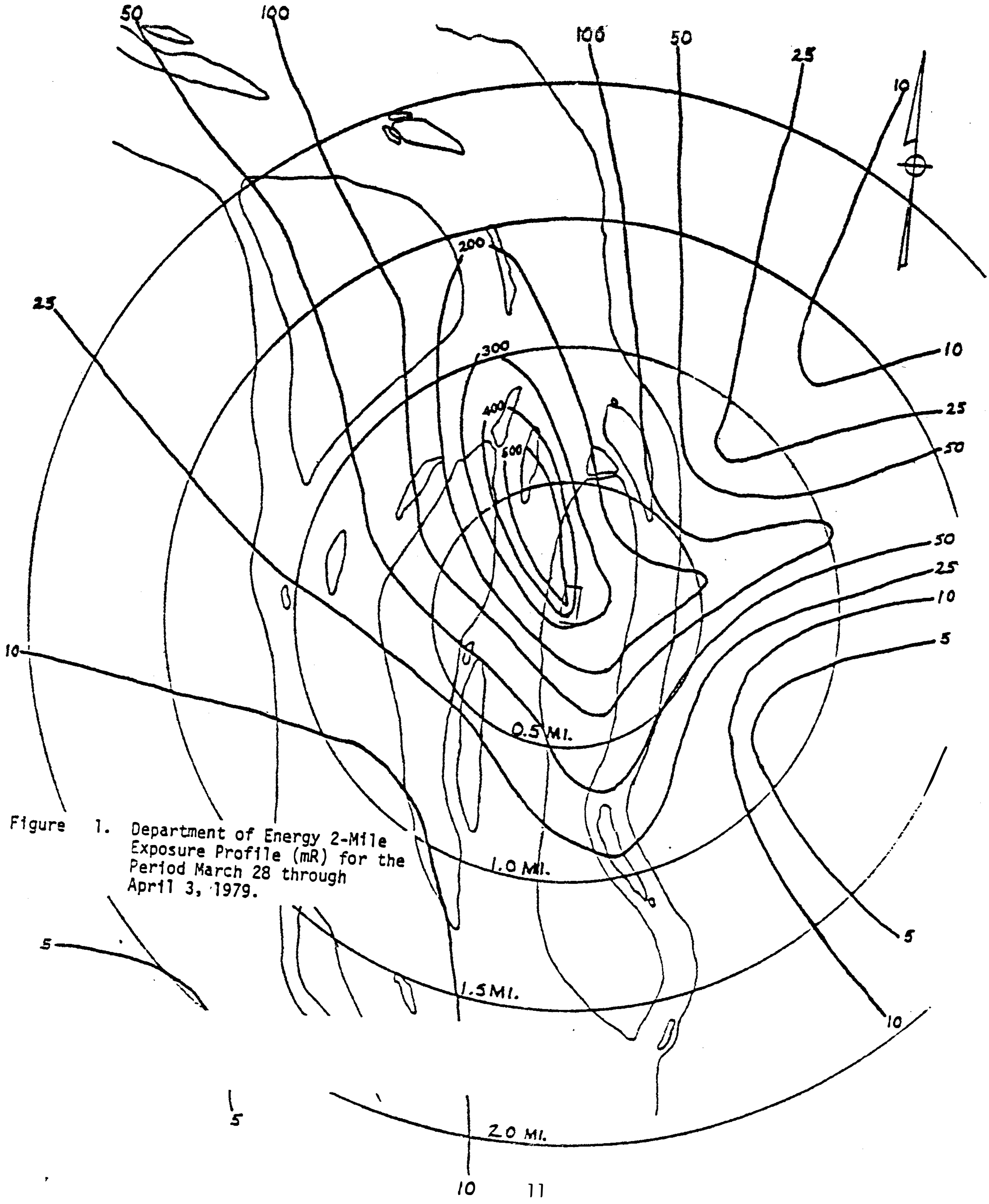


Figure 1. Department of Energy 2-Mile Exposure Profile (mR) for the Period March 28 through April 3, 1979.

to March 29, 8 a.m., and the second one being March 29, 8 a.m. to March 31, 4 a.m. The method that was used is described in detail in Reference 2, and briefly is as follows.

The onsite meteorological measurements were used in conjunction with the meteorological models described in NRC Regulatory Guide 1.111[4] to estimate the meteorological dispersion factor, X/Q, at each field TLD location. In theory the dose accumulated on each TLD (background subtracted out) divided by the X/Q value at the location should be the same for each location for a given time period. The average wind-frequency weighted value of this quotent was determined for all the dosimeters, and the results of the distribution was used to characterize the dose at all locations. Multiplication of this weighted average value by the X/Q value at any location results in an estimate of the γ dose at that location.

The accumulated dose for each period appears in Table 4 of Reference 2. The following table (Table 3) was based on the data of Table 4 of Reference 2, and presents the estimate of dose for the sum of the two periods for areas close to the plant.

3. <u>Assessment by Pickard, Lowe, and Garrick</u>[3]

The approach used by Pickard, Lowe, and Garrick, Reference 3, to estimate the spatial dose distribution is similar in some

Table 3

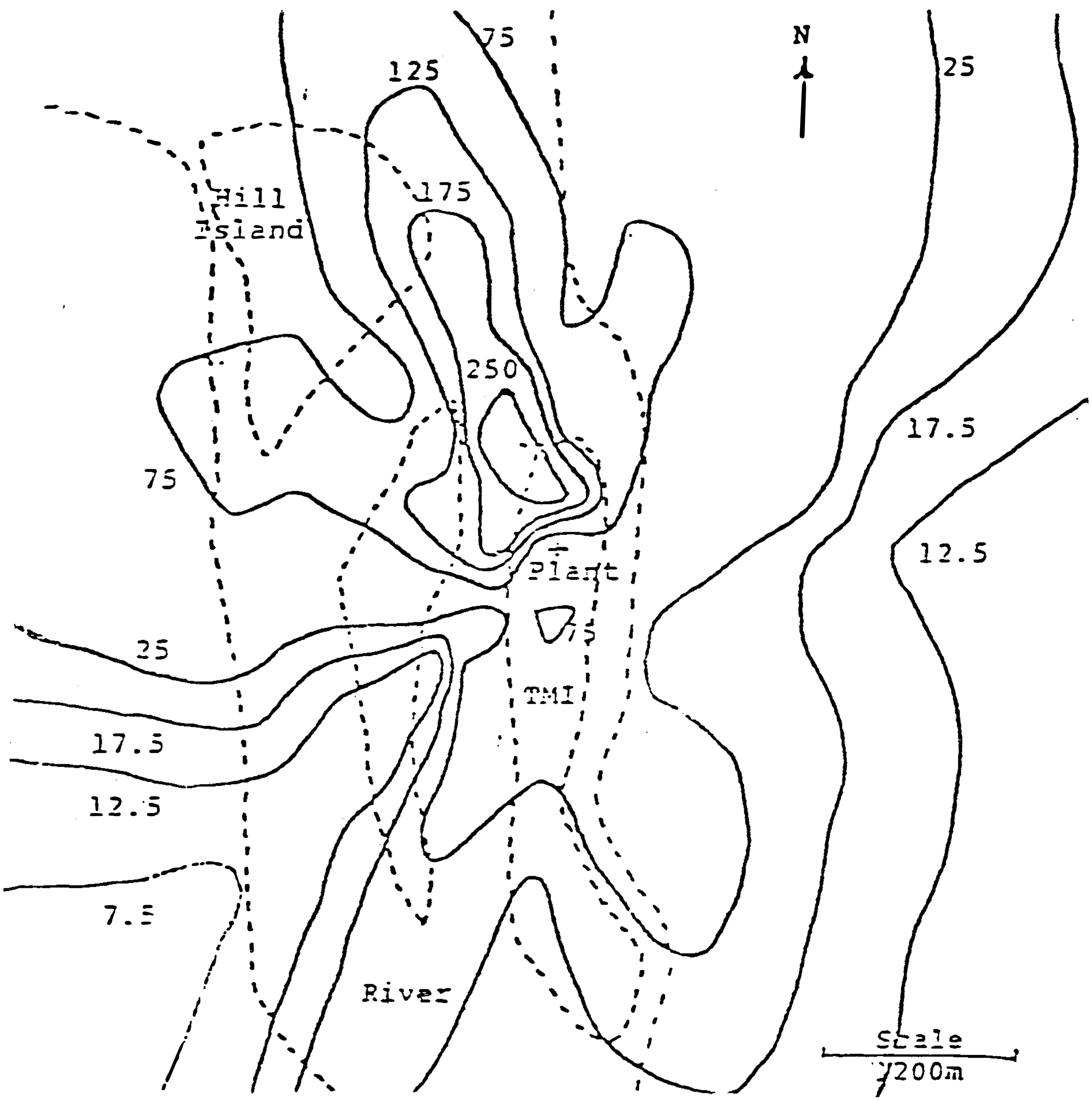
Calculated Doses (mR)

Sector/Distance (miles)	Doses (mR) 0.5	1.0	2.0
N	307.	90.	29.
NNE	154.	44.	14.
NE	51.	15.	5.
ENE	41.	12.	4.
E	30.	8.	3.
ESE	36.	10.	4.
SE	46.	14.	5.
SSE	86.	26.	9.
S	102.	31.	10.
SSW	131.	40.	13.
SW	114.	34.	11.
WSW	402.	121.	40.
W	460.	142.	48.
WNW	517.	157.	52.
NW	376.	115.	37.
NNW	360.	110.	36.

respects to that used by the Radiological Assessment Branch Staff. The Pickard, Lowe, and Garrick method is described in detail in their report[3], and is briefly as follows. They used the area radiation monitors activity recordings as a relative measure of the rate of release of activity. This relative measure of activity released over time was converted into an absolute time varying release rate by an iterative procedure employing the following steps: (1) Determine relative quantities of each isotope with respect to the predominent isotope, Xe-133 using the ORIGEN computer code.[6] (2) By utilizing the dose equivalent relationship, determine the relative release rate of each isotope. (3) Establish a set of trial releases for each isotope proportional to the Xe-133 release rate, along with the meteorological dispersion model described in NRC Regulatory Guide 1.111[4], and calculate doses at each TLD monitoring station based on models in NRC Regulatory Guide 1.109[5]. (4) The results of the computed dose at each TLD monitor are compared to those recorded on the monitors, and the absolute value of the source term is adjusted to give the best possible fit. (5) Once the best time varying source term is defined, it is used in models described in NRC Regulatory Guides 1.109 and 1.111 to estimate the dose profile around the plant.

Figure 2 was taken from the Pickard, Lowe, and Garrick report and displays the cumulative spatial dose distribution for the time period over which most of activity was released.

Figure 2



Dose is the total dose from all activity due to the accident which was released thorugh April 6. This is more than 99% of all such activity released through April 30.

c) Dose Estimates

1. Best Estimates

Each of these reports contain either estimates of what the maximum offsite dose was or data by which such estimate can be made. In the interagency report the maximum exposed individual was estimated to have received 37 to 93 mrem, and was located on Hill Island. Higher exposure rates would have occurred on Kohr Island, as that island is closer to the plant, but it is known that Kohr Island was uninhabited.[1] Other close places that received the highest doses, according to Reference 1, were in the ENE sector (83 mrem) and the SSE sector (less than 41 mrem). The doses calculated for these places are based on the assumption of a hypothetical individual being outdoors for the entire release period, and thus does not represent a best estimate of exposure. Figure 3 was taken from Reference 1 and depicts these locations. The values given for Hill Island above represent a true best estimate because the actual time that the individual was outdoors was factored in.*

From the Department of Energy exposure profiles, Figure 1, the maximum exposed individual would have been expected to have been on Hill Island (less than

*It was confirmed that only one individual was on the island. He stated that he was the only person on the island after the accident and was present for 9-1/2 hours (from 11:00 a.m. to 4:30 p.m. on March 28 and from 11:00 a.m. to 3:00 p.m. on March 29).[1]

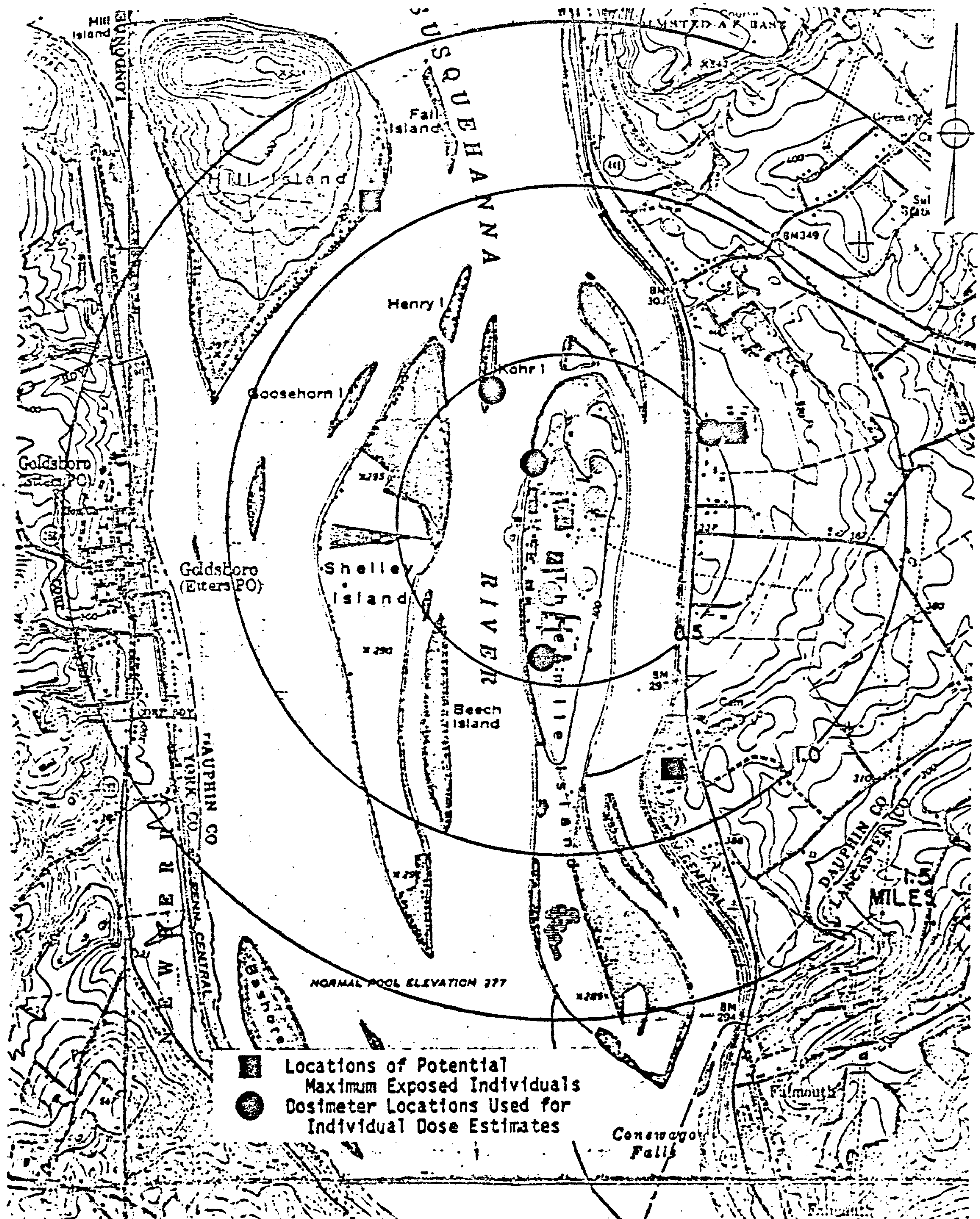


Figure 3 Sites of Potential Maximum

100 mrem), or along the east bank of the Susquehanna River (less than 100 mrem except for one spot which is in the 200 mrem isopleth). These values are in general agreement with those of the Ad Hoc Assessment Group[1] when instrument calibration is taken into consideration.

Inspection of the results of the RAB staff analysis appearing in Table 3 suggests that the maximum doses occurred along the east bank of the river, or on Hill Island. The values are only slightly larger than those above, with a maximum of around 160 mrem for a hypothetical individual that remained outdoors continuously. To achieve a best estimate this number has to be reduced to allow for shielding from buildings. A better estimate based on this analysis would be to reduce it by a factor of 0.7* resulting in 112 mrem.

The Pickard, Lowe, and Garrick Report[3], presents results of calculations due to γ noble gas exposure at many offsite locations. Three of interest are along the east bank of the river (43 mrem ENE), near Goldsboro on the west bank of the river (21 mrem, W), and at Middletown (30 mrem). Inspection of the entire dose distribution (Figure 2) indicates that their maximum dose due to noble gas emissions is about 75 mrem in

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*NRC Regulatory Guide 1.109 lists the shielding factor for the maximum exposed individual to be 0.7.[5]

several sectors; namely, the WNW, NNW, and NNE directions. These estimates are conservative in that they do not take into consideration shielding for buildings, hence, the values should be somewhat lower. The results here are in general agreement with those of the previous analyses.

Table 4 summarizes the best estimates from four separate analyses for the maximum exposed individual. There are several conservatisms which cannot be absolutely quantified but can only be approximate as noted in the footnotes, nonetheless, their effect should be considered. When they are, the results of all of these analyses are in excellent agreement, and the best estimate of maximum exposure is probably less than 70 or 80 mrem.

Table 4

Summary of Best Estimates of Maximum Exposed Individual

	Dose (mrem)		
	Hill Island	NE Quadrant	SE Quadrant
DOE Helicopter	<100*‡†	<200*‡	<100*‡
Interagency Report	43-93	83‡	41‡
RAB Staff Analysis	<112	50	86
Pickard, Lowe & Garrick Report	75‡†	75‡	25‡

*These values may be overestimated by as much as a factor of 3 because of instrument calibration.

‡These values should be reduced 30% to take into consideration shielding from buildings, i.e., limited outdoor exposure.

† These values should be reduced to take into consideration the limited time

2. Upper Bound Estimate for 10 CFR 140.84 Criterion

While the previous section presents the best estimate of dose due to the noble gas releases, this section presents an analysis based on a hypothetical human behavior scenario which assumes that an individual was near the plant during the entire release period, and in the plume in the downwind sector where the dose would be expected to be highest. This scenario is chosen not to be realistic but to establish an upper bound to the best estimate for the 10 CFR 140.84. determination.

The human behavior scenario that is assumed is that a person in a boat is located on the perimeter of Three Mile Island for the entire course of the releases, and that the individual will move the boat to keep it under or in the plume in the downwind sector at all times. This will result in significantly more dose to the hypothetical individual than could have occurred to an actual person near the plant located at a fixed location or moving about in a random fashion. This is because the dose at a fixed point in space is accumulated at that point only when the plume is located in, or near the direction of the point in question. If an individual managed to stay in the plume by moving around with it as it changed direction, the individual would receive considerably more dose than would be estimated by simply taking a value at a fixed location.

To calculate the dose the individual in the boat would receive it is necessary to add up the dose in each sector at the island perimeter. The DOE exposure profiles will be used for this calculation. It should be noted that the DOE profiles indicate doses larger than those of the other two analyses presented above, but if the DOE values are decreased by a factor of 3 because of instrument over response, the DOE results are very similar to those in references 2 and 3. Table 5 lists the values taken from Figure 1 (before adjustment for instrument calibration) for this calculation.

The sum of the values of Table 5 represent the upper possible limit, and is equal to 4.7 rem total body. To take into consideration instrument calibration, all the numbers of Table 5, except the 1 value in the table from reference 3, should be reduced by about a factor of 3. This leads to an estimate of 2.3 rem.

Table 5*

Sector	Approx. Distance (miles)	Approx. Dose (mrem)
N	0.50	300
NNE	0.50	150
NE	0.34	200
ENE	0.28	260
E	0.24	270
ESE	0.26	220
SE	0.30	180
SSE	0.50	80
S	1.30	15
SSW	0.28	100
SW	0.18	240
WSW	0.10	300
W	0.08	440
WNW	0.10	400
NW	0.11	500
NNW	0.19	1050**

* Data in this table taken from Figure 1 (DOE helicopter G-M tube readings).
**This value taken from report by Pickard, Lowe, and Garrick[3] and represents dose accumulated on TLD at this location.

II. Iodine

a) Introduction

This section provides estimates of doses due to inhalation of I-131 due to a plume passing over populated areas. It also provides estimates of the amount of the iodine that could settle onto the ground surface, thereby providing contamination estimates, as well as dose estimates due to direct shine from the ground plane. In the section which deals with inhalation dose estimates, both realistic "best estimates" are made for a hypothetical individual, as well as estimates which are designed to provide upper bounds for the best estimates. In the sections where deposition contamination and ground shine dose estimates are made, only upper bound estimates are made. The sections on dose and ground contamination are preceded by two sections, one which deals with source term estimates and the other which deals with the meteorological models that are used.

There are two areas relating to I-131 releases which are not covered in this report. They are: (1) the iodine doses due to consumption of milk and (2) ground contamination outside the permanent fence but on Three Mile Island. The milk pathway is not treated here because many milk samples were taken during the releases, and after them, which well document that the doses were below the 30 rem thyroid level set by 10 CFR 140.84.[1,3] Ground contamination calculations on Three Mile Island outside the perimeter fence were not made here but are included as a separate analysis as they are based on actual field samples rather than calculational methods.

b) Source Term Estimates

Estimates of the iodine-131 source term resulting from the March 28 accident at TMI-2 have been well documented[3,8,9] since direct estimation of the plant iodine releases was feasible. These estimates were made by continuously sampling the Unit 2 vent effluent streams, Radiation number (HPR-219),* by drawing a small side stream through a charcoal cartridge which traps iodine and subsequently analyzing the cartridges in the laboratory to determine iodine loading on the cartridge. The charcoal cartridges were changed at frequent intervals following the accident. From this information iodine concentrations in the ventilation air leaving the plant were determined. Estimates of the iodine-131 releases have been made by both the NRC and Metropolitan Edison who have independently analyzed the charcoal cartridges removed from Three Mile Island.

Iodine-131 release estimates made by the three reports referenced above agree well. The maximum estimate of the total I-131

*As discussed in the TMI-2 Final Safety Analysis Report[21], HPR-219, located in the plant vent stack, was designed to measure particulate, iodine and noble gas releases from the reactor building, fuel handling building and auxiliary building ventilation systems and from the waste gas and condenser air ejector exhausts.

released among these 3 references was that of Reference 9 (15 curies). Reference 9 presents the time dependent releases of iodine-131 following the accident based on actual measurements from the charcoal cartridge at HPR-219. For a few short periods when continuous samples were not available, linear interpolation was used from the surrounding time periods that would maximize the release for that period. In this manner, release estimates are made continuously through May 6, 1979. Further releases after this time contributed negligibly to the total curies released as a result of the use of the supplementary filtration system on May 1, the capping of the plant vent on May 19, and the continuing radioactive decay of the activity in the plant results in negligible releases after May 6.

In Reference 9, quantities of radioactive iodine are given for 112 time periods beginning at 4:00 a.m. hours on March 28 consecutively progressing through May 8, 12:00 p.m. During this entire period the highest release rate occurred during the period beginning at 7:00 p.m. hours on March 28 through 10:00 p.m. hours on March 30. The average release rate for this period was 0.081 Ci/hr. In the upper limit calculations of dose and ground contamination which follow it is assumed that this release rate occurred over the entire period covered by the calculation. If this release rate had occurred for the entire 43 day period the total activity released would have been about 84 curies. Since the actual total activity released was about 15 curies[9], this approach is conservative by about a factor of 5.7.

c) Meteorological Model and Results

The meteorological data collected onsite at TMI's meteorological tower during the course of the accident provided the bases for the estimated joint frequency distribution of wind speed and wind direction by atmospheric stability class. These distributions were used to evaluate the average relative concentration (X/Q) and relative deposition (D/Q) distributions with distance in each of 16, 22.5 degree sectors surrounding the site. Evaluations were made for the time period: 4:00 a.m. March 28 through 4:00 a.m. May 9, 1979. Hourly meteorological data also allowed the calculation of relative concentrations and relative deposition for use in the dose calculations for specific points surrounding the site.

The diffusion calculations used Gaussian plume and deposition models described in Regulatory Guides 1.145[18] and 1.111.[4] The assumptions that were used apply to both the centerline (R.G. 1.145) and sector spread model evaluations (R.G. 1.111) and are as follows:

1. All radioactive gaseous releases occurred at ground level, and thus were subject to lighter winds and the existence of more stable vertical dispersion conditions than elevated releases. Therefore, this assumption minimizes

plume diffusion rates and maximizes ground level concentration estimates. This assumption can result in overestimates of ground level concentration and deposition by as much as a factor of 10.

2. Effluent plumes are transported in a straight line direction as indicated by the onsite wind direction. Due to the short distances involved in the evaluation, this assumption provides reasonable assurance that wind directions reported from the onsite instrumentation indicated the true effluent transport direction.

3. All hourly periods of missing data were omitted from the calculations. The data review indicated some periods, totaling 51 hours in May, with suspected incorrect data either in atmospheric stability or wind measurements existed and no attempt was made to estimate appropriate values for these periods. Thus, the periods were ignored in the calculations. The impact of ignoring these missing periods in the computations is expected to be insignificant (i.e., less than $\pm$ 20-30%).

4. In order to account for the possible effects of air flow recirculation of effluents, a factor of four has been applied to the values of relative concentration and deposition. These adjusted estimates are not expected to be as great as two times the value that actually occurred for the point of interest.

5. The effects of precipitation were not included in the calculations. Any precipitation that occurred during the release could cause some of the effluent, particularly iodines, to be washed out at the points of interest. Precipitation in the TMI vicinity was observed in the form of light rain and drizzle beginning at midnight on March 29 and continuing until 3:20 a.m. that day, which accounts for the only rainfall during the time of greatest I-131 release. This rainfall, as well as that which occurred during April 1-3, would be expected to deplete the airborne radioiodine concentration and increase the deposition at the points of interest. However, due to the short distances to the points of interest, the small fraction of release time during rainfall periods, and the low rainfall rates, this rainfall impact on X/Q and D/Q estimates should be small within a factor of a few, and was not included.

Relative concentration (X/Q) and deposition (D/Q) estimates were made using joint frequency representations of wind speed, direction and stability. Values were estimated based upon hourly meteorological data in a conservative manner by using average relative concentration and deposition values in a particular direction during the entire 43 days of release.

In establishing the final concentration and deposition estimates, the hourly calculations of X/Q and D/Q using the sector spread (R.G. 1.111)[4] and centerline methods (R.G. 1.145)[18] were compared and the maximum values were selected for use in the deposition calculations. This selection method provides additional assurance that the X/Q and D/Q values are conservative.

Based on our assessment of the assumptions cited above, the atmospheric concentration and deposition estimates are expected to be conservative by a factor ranging from two to ten depending on the particular location considered.

d) Dose and Deposition Estimates

1. Inhalation

i. Best Estimate

To obtain a best estimate of the I-131 air inhalation dose the time varying source term of Reference 10 was coupled with the time varying estimates of meteorological dispersion, as described in Section B.II.c, to obtain concentration values of I-131 in space and time. From these concentration values, time averaged values were computed for several locations near Three Mile Island. Table 6 lists these locations along with the time-averaged concentration expected to have occurred at them for the period of March 28 through April 30. The values in this table were based on data taken from Reference 11.

Table 6

Time-averaged I-131 Air Concentration

Sector	Distance (mi.)	Concentration ($\mu Ci/m^3$)
SW	2.6	2.40×10^{-6}
NNE	2.2	2.60×10^{-6}
NE	2.5	2.48×10^{-6}
SE	1.5	4.13×10^{-6}

To calculate the best estimate of exposure, the value for concentration that is used is $10^{-5} \mu Ci/m^3$. This value was chosen for conservatism from the values in Table 6 and is larger than any of the values in it. The dose factor and inhalation rates of NRC Regulatory Guide 1.109 were used resulting in Table 7. In addition to the maximum expected exposures the table lists the 10 CFR 140.84 levels. Comparison of the calculated values to the levels indicates that these best estimates exposures were well below the levels.

Table 7

Best Estimate of Maximum Exposure

Iodine Doses (rem)

Age Group	Thyroid	Whole Body	Bone	Skin	Liver	Kidney	Lung	GI-LLI
Infant	.017	0	0	0	0	0	0	0
Child	.019	0	0	0	0	0	0	0
Teen	.017	0	0	0	0	0	0	0
Adult	.014	0	0	0	0	0	0	0
10 CFR 140.84 Level	30.	20.	20.	60.	30.	30.	30.	30.

The results of these calculations are in agreement with those presented in the interagency report.[1] In that report estimates of the thyroid dose a child could have received (this age group receives the maximum dose) from inhalation of I-131 at the observation center (0.5 mi. SSE) for the period of March 29 through April 3 was about 2 mrem. If a similar approach is used as was done for Table 7 to calculate the period of March 29 through April 3 at the observation center, the child thyroid dose comes out to be about 2 to 3 mrem, in close agreement with the interagency report estimate.

The results of the ground concentration calculations are also in good agreement with those of Pickard, Lowe, and Garrick.[3] Their calculations indicated the maximum time average concentration to be about $6.6 \times 10^{-6} \mu Ci/m^3$ for the period of March 28 through April 30, which is close to the values of Table 6.

ii. Upper Bound Estimate for 10 CFR 140.84 Criterion

Computation of doses via the iodine air inhalation pathway for an upper bound for the best estimate is made here in two ways. The first assumes that an individual was located just offsite for a continuous 43 day period starting at the onset of the accident through the entire release period. The second is for close-by populated land masses. In this latter calculation it is also assumed that the individual is exposed continuously over the entire release period (approx. 43 days). The first approach is intended to apply to a hypothetical individual who could have been near Three Mile Island. However, it is very unlikely that anyone was on the island for the entire time period. The second approach is intended to apply to residents located near the shoreline involved in recreational and other activities.

The inhalation doses calculated here are based on the maximum release rate that occurred during the entire 43 day release period, rather than using the average actual release rate. This introduces a factor of conservatism of about 5.7 into the calculations.* In addition to this conservatism, meteorological dispersion parameters are used which incorporate conservative recirculation factors. Table 8 gives the values of X/Q at the exclusion boundary distances for each sector for the 43 day time period.

*The actual activity released during the first 43 days was approximately 14.8 curies, whereas based on the maximum release rate the amount that is input to this calculation is 84 curies. The ratio of the input value to the actual value is a measure of the conservatism introduced into the calculation and is about 5.7.

Table 8

Meteorological Dispersion Parameters

Sector	Distance (mi.)	X/Q (sec/m^3)*
N	.24	9.2×10^{-5}
NNE	.32	5.4×10^{-5}
NE	.25	4.5×10^{-5}
ENE	.21	8.3×10^{-5}
E	.20	8.2×10^{-5}
ESE	.21	7.6×10^{-5}
SE	.23	7.5×10^{-5}
SSE	.32	4.1×10^{-5}
S	.32	8.7×10^{-7}
SSW	.20	6.3×10^{-7}
SW	.13	7.4×10^{-7}
WSW	.11	1.2×10^{-6}
W	.11	1.9×10^{-6}
WNW	.11	1.6×10^{-6}
NW	.12	1.6×10^{-6}
NNW	.13	1.3×10^{-6}

*Values are time averages over first 43 days of releases.

The calculation of the doses which follow are based on the X/Q in the sector where it has a maximum value (N sector), and on the dose factors contained in NRC Regulatory Guide 1.109. Table 9 lists these results along with the level set in 10 CFR 140.84.

Table 9

Upper Bound of Dose for 10 CFR 140.84 Criterion

Iodine Doses (rem)

Age Group	Thyroid	Whole Body	Bone	Skin	Liver	Kidney	Lung	GI-LLI
Infant*	--	--	--	--	--	--	--	--
Child	3.9	.006	.011	--	.010	.019	--	0
Teen	3.5	.008	.008	--	.011	.020	--	0
Adult	2.9	.006	.006	--	.008	.015	--	0
10 CFR 140.84 Level	30.	20.	20.	60.	30.	30.	30.	30.

*Calculations are not made for infant because it is inconceivable that an infant was anywhere near the exclusion boundary, however, calculations for all age classes are made below for the nearest populated areas.

Table 9 indicates that the doses are all well below the 10 CFR 140.84 level, especially in consideration that these values are conservative by at least a factor of 5.7 because of the larger than estimated actual release rate that was used. In the section on noble gas exposure the upper bound dose estimate was made by assuming that an individual moved as the wind shifted and stayed downwind of the plant in the plume. If the adult thyroid dose is calculatd based on this kind of scenario the result is about a factor of 6 larger (less than 18 rem) than that of Table 9. The basis of this calculation was that the individual was just offsite for the entire 43 day period always staying in the downwind sector. This number is presented only for consideration and is not used below as is is based on an unrealistic scenario of human activity.*

*The scenario of an individual moving around to stay in the plume is more realistic for the noble gas releases because the duration of the noble gas releases was short (most over a three day period) and the dispersion occurred in three predominent directions. Hence, if an individual was in a boat for several days in the direction where doses would be expected to be highest, the estimate developed by this scenario would be larger but representative of the actual dose the individual would have received. In the case of the iodine releases which lasted 43 days, there was no predominent direction in which most of the material was dispersed in comparison to the noble gas releases, hence, for a person to receive this dose would require knowledge of the plume location and a desire to stay in it. In the judgment of the authors this scenario is unrealistic.

The inhalation dose is calculated for an individual along the nearby shorelines where the general public has access on the basis that an individual is exposed during the entire 43 day release period as was done in the calculation above.* The release rate that is used was the same as for the previous calculation and introduces the same factor of conservatism of 5.7. As in the preceding section, there were also very conservative approaches taken in development of the meteorological parameters (overestimates of recirculation). Table 10 lists the time averaged (43 day) values of X/Q at several nearest public access shoreline locations that are used in these calculations.

Table 10

Meteorological Dispersion Parameters

Sector	Distance (mi.)	Description	X/Q (sec/m^3)*
N	1.20	East shoreline	1.21×10^{-5}
NNE	0.80	East shoreline	2.32×10^{-5}
NE	0.50	East shoreline	2.31×10^{-5}
E	0.50	East shoreline	3.24×10^{-5}
W	1.30	Goldsboro shoreline	1.26×10^{-5}
WNW	1.20	Goldsboro shoreline	1.17×10^{-5}
NW	1.20	Hill Island shoreline	1.10×10^{-5}
NNW	1.20	Hill Island shoreline	8.02×10^{-6}

*Values are time averages over the 43 day release period.

*The iodine releases were made during the first 43 days after the accident. Negligible releases occurred after this period as noted in Section B.II.b.

The calculation of the dose is based on the X/Q at the location of Table 10 where it has the maximum value (E sector). The dose factors were taken from NRC Regulatory Guide 1.109. Table 11 lists the results of the calculation for each age group and organ. Also in the table are listed dose levels of 10 CFR 140.84.

Table 11

Upper Bound Estimates of Dose for 10 CFR 140.84 Criterion

Iodine Doses (rem)

Age Group	Thyroid	Whole Body	Bone	Skin	Liver	Kidney	Lung	GI-LLI
Infant	1.3	.002	.003	--	.004	.004	--	0
Child	1.4	.002	.004	--	.004	.007	--	0
Teen	1.3	.002	.003	--	.004	.007	--	0
Adult	1.0	.002	.002	--	.003	.005	--	0
10 CFR 140.84 Level	30.	20.	20.	60.	30.	30.	30.	30.

The table indicates that the doses are all well below the 10 CFR 140.84 level.

2. Deposition

This appendix does not present a best estimate of possible ground contamination, but only presents an upper bound estimate. A best estimate is not calculated here because the results of the upper bound estimate are very small. This calculation is conservative for two reasons (1) over conservative estimates of the meteorological deposition parameter, D/Q, are calculated as described in Section B.II.c, and (2) the maximum instantaneous release rate was used for the entire period. The results of the D/Q calculations are presented in Table 12 below, and represent the time averaged deposition parameter for the 43 day release period. The locations in the table represent ones which are along adjacent shorelines where deposition is expected to be greatest.

Table 12

D/Q for Several Locations

Sector	Distance (mi.)	Description	D/Q (m^{-2})*
N	1.20	East shoreline	1.49×10^{-8}
NNE	0.80	East shoreline	3.87×10^{-8}
NE	0.50	East shoreline	2.92×10^{-8}
E	0.50	East shoreline	5.03×10^{-8}
W	1.30	Goldsboro shoreline	1.70×10^{-8}
WNW	1.20	Goldsboro shoreline	2.48×10^{-8}
NW	1.20	Hill Island shoreline	1.89×10^{-8}
NNW	1.20	Hill Island shoreline	1.61×10^{-8}

*Time averaged values for 43 day release period.

To calculate the ground concentration, c, at any time, t, after the onset of the accident, the following equation is used:

$$\frac{dc}{dt} + c\lambda_I = \left(\frac{D}{Q}\right) Q_m \qquad (1)$$

where,

λ_I = decay coefficient for I-131

Q_m = maximum release rate over period*

The solution of Equation (1) is

$$c = \left(\frac{D}{Q}\right) \frac{Q_m}{\lambda_I}\left(1 - e^{-\lambda_I t}\right) \qquad (2)$$

Equation (2) gets monitonically larger with time, hence, the largest ground concentration that could occur, is when $e^{-\lambda_I t} = 0$ and, and has the value,

$$c = \left(\frac{D}{Q}\right) \frac{Q_m}{\lambda_I} \qquad (3)$$

Calculating the concentration from Equation (3) D/Q values of Table 12 results in estimates of ground contamination (Table 13). The value of Qm that was used is 0.081 Ci/hr and the value of λ_I for I-131 is $3.61 \times 10^{-3}\ hr^{-1}$.

Table 13

Upper Bound Estimates of I-131 Ground Contamination

Sector	Distance (mi.)	Description	Concentration ($\mu Ci/m^2$)
N	1.20	East shoreline	0.33
NNE	.80	East shoreline	0.86
NE	.50	East shoreline	0.65
E	.50	East shoreline	1.11
W	1.30	Goldsboro shoreline	0.37
WNW	1.20	Goldsboro shoreline	0.55
NW	1.20	Hill Island shoreline	0.42
NNW	1.20	Hill Island shoreline	0.35

*The maximum release rate results in the introduction of significant conservatism in results. This is approximately a factor of 5.7.

Because I-131 decays into Xe-131 m, and the Xe-131 m then dacays with its own radioactive emission, it is necessary to calculate the ground contamination of Xe-131 m as well. A conservative estimate of the Xe-131 m concentration can be obtained as was done for the iodine. The equation that is obtained is as follows:

$$C = 0.143 \left(\frac{D}{Q}\right) \frac{Q_m}{\lambda_I - \lambda_x} \qquad (4)$$

where,

λ_x = decay coefficient for Xe-133 m

Table 14 lists the maximum concentrations for Xe-131 m calculated by Equation (4). The value of λ_x that was used was 2.44×10^{-3} hr^{-1}.

Table 14

Upper Bound Estimates of Xe-131 m Ground Contamination

Sector	Distance (mi.)	Description	Concentration ($\mu Ci/m^2$)
N	1.20	East shoreline	.15
NNE	.80	East shoreline	.38
NE	.50	East shoreline	.29
E	.50	East shoreline	.49
W	1.30	Goldsboro shoreline	.17
WNW	1.20	Goldsboro shoreline	.24
NW	1.20	Hill Island shoreline	.18
NNW	1.20	Hill Island shoreline	.16

Calculation of the dose rate, H, due to deposition on the ground plane for the 10 CFR 140.84 criterion was made as follows:

$$H = c(DF) \quad (5)$$

DF is the dose factor for absorption of tissue measured through not more than 7 mg/cm^2 of absorber (10 CFR 140.83), and c is the activity per unit area. The dose factors for I-131 decay are 1 X 10^6 mrem cm^2/yr-μCi for γ emission, and 3 X 10^7 mrem cm^2/yr-μCi for β emission, and the dose factors for Xe-131 m decay are 2.2 X 10^5 mrem cm^2/yr-μCi for γ emission, and 4 X 10^7 mrem cm^2/yr-μCi for β emission.[17] The value of c that was used for I-131 was the maximum value of Table 13 (1.11 μCi/m^2) and the value of c that was used for Xe-131 m was the maximum value of Table 14 (0.49 μCi/m^2). This results in a combined γ dose rate of 0.027 mrem/hr and a combined β dose rate of 0.6 mrem/hr.** Both of these numbers are well below the 10 CFR 140.84 level of 4 mrad/hr.*

---

* For γ and β emitters rads are equivalent to rems. (10 CFR 20.1)

**For I-131 the γ dose rate was .013 mrem/hr and the β dose rate was 0.38 mrem/hr. For Xe-131 m the γ dose rate was .001 mrem/hr and the β dose rate was 0.22 mrem/hr.

3. Ground Shine

The dose that a person receives from standing on ground contaminated with I-131 or Xe-131 m is calculated here by methods described in Regulatory Guide 1.109. For I-131 the total body external dose factor is 2.8×10^{-9} mrem-m^2/hr-pCi and the skin external dose factor is 3.4×10^{-9} mrem-m^2/hr-pCi. For Xe-131 m the external dose factor for total body is approximately 6.2×10^{-10} mrem-m^2/hr-pCi and for skin is approximately 1.4×10^{-9} mrem-m^2/hr-pCi.

To calculate the dose received by an individual the maximum values for ground contamination listed in Tables 13 and 14 are used. Further, it is assumed that these concentration levels remain constant throughout the entire 43 day release period, which results in a significant overestimate of dose. This is because the ground concentrations early on were much lower as they slowly increased to their maximum values, and late in the release period, as the release rates decreased, and the ground contamination decayed away. This calculational approach leads to results listed in Table 15 and are conservative for the same reasons the ground concentration estimates are conservative in addition to the conservatism discussed above.

Table 15

Upper Bound Estimates of Doses Due to Ground Shine

	Doses (Rem)	
	Total Body	Skin Dose
I-131	3.2×10^{-3}	3.9×10^{-3}
Xe-131 m	3.1×10^{-4}	0.7×10^{-3}
Total	3.5×10^{-3}	4.6×10^{-3}

These values are well below the 10 CFR 140.84 dose levels of 20 rem whole body and 60 rem skin.

C. AQUATIC RELEASES

An analysis of the releases and dose consequences of radionuclides into the Susquehanna River from the plant during the accident was made by the NRC Radiological Assessment Branch Staff.[10] The assessment presents detailed information of the releases made during the period of March 28, 1979, through May 11, 1979. It also evaluates the health and environmental consequences of those releases. It presents methods used to determine the maximum doses that an individual would receive as a result of ingestion of water and fish flesh. The results of these calculations were well below the levels set in 10 CFR 140.84.

The general approach that was used in this report was as follows. Metropolitan Edison Company and their consultants provided the results of analyses which were performed on the various flow discharge paths during the accident. Daily flow rates coupled with concentration measurements allowed calculation of daily activity release rates. The concentration of radionuclides in the discharge was diluted with 10% of the average daily river flow. (The full river flow was not used to assure conservatism.) Based on this assumption the dose equivalent an adult individual would be expected to receive by consuming one liter of this water per day for a sixty day period amounted to about 1.3×10^{-6} rem. A similar calculation for fish consumption was done, and was based on fishes equilibrating in this water, and a consumption rate of .25kg of fish per fish dinner. It was assumed that 2 fish dinners could be eaten per day. For a sixty day period the resulting dose is 6.2×10^{-4} rem. These calculated doses are so far below the 10 CFR 140.84 levels that they are not included in the discussion below.

D. DISCUSSION OF RESULTS

In this section the calculations made in previous sections are summarized for the purpose of the 10 CFR 140.84 finding. The dose calculations which are presented in this section are not the best estimates that were calculated above, but are the upper bound estimates. Table 16 summarizes the results of the dose calculations, and Table 17 summarizes the results of the ground contamination calculations. In the last row of each table the 10 CFR 140.84 levels are listed for comparative purposes.

It should be noted that, although the values appearing in the "total" row of Table 16 are a sum of all the doses in the above rows, for a hypothetical person to get that much dose, it would be necessary for the person to be in two places at once. Hence, the values in the total row are unrealistic from this standpoint as well as conservative for the reasons already noted. Comparison of the total rows in each table to the rows where the 10 CFR 140.84 levels are listed indicates that the releases were well below these levels.

Table 16

Upper Bound Estimates of Dose

Nuclide/ Pathway	Location	Period	Dose (rem)** Total Body	Thyroid	Skin
Noble Gas External exposure	Perimeter of TMI	Initial 3 days	2.3	2.3	4.7*
I-131 Inhalation	SW Sector Exclusion Boundary	Initial 43 days	.008	3.9 +	.008
I-131 Inhalation	East shore of Susquehanna River	Initial 43 days	.002	1.4	.004
I-131 Ground Shine	East shore of Susquehanna River	Initial 43 days	.003	.003	.004
Xe-131 m Ground Shine	East shore of Susquehanna River	Initial 43 days	0	0	.005
Total	---	---	2.32	7.6	2.42
10 CFR 140.84 Levels	---	---	20.	30.	60.

* This value was calculated by multiplying the ratio of the β skin dose factor by the γ total body dose factor for Xe-133[5], by the total body dose and adding the γ total body dose to it.

**The calculated dose due to releases into the aquatic environment are not included in this table as the combined dose due to fish consumption and drinking water is negligible (.001 rem).

+On page 34 a thyroid dose was presented which was based on an unrealistic scenario for human behavior which assumed that an individual stayed in the downwind sector for the continuous 43 day period during which the releases were made. While this value is larger than the thyroid dose values in the table, it is not used here as a basis for the 140.83 determination as the human behavior scenario is too unrealistic in the judgment of the authors.

Table 17

Upper Bound Estimates of Ground Contamination

Nuclide	Location	Period	Dose Rate (mrem/hr) Gamma	Beta
I-131	East shore at Susquehanna River	43 days	.013	.38
Xe-131 m	East shore at Susquehanna River	43 days	.001	.22
Total	East shore at Susquehanna River	43 days	.014	.60
10 CFR 140.84 Level	---	---	4.0	4.0

As noted in previous sections, calculations are not made in this report for doses due to the I-131 milk pathway because many milk samples were taken during and after the releases, which well document that the doses were very small compared to the 10 CFR 140.84 level.[1,3] The one other area in which calculations are not made in this report is for ground contamination on Three Mile Island outside the perimeter fence. These locations are too close to the source for effective meteorological modeling, hence, these estimates must be based on actual field samples. These estimates are discussed in a separate appendix.

E. REFERENCES

1. Ad Hoc Interagency Dose Assessment Group, "Population Dose and the Health Impact of the Accident at Three Mile Island Nuclear Station," May 1979, Report NUREG-0558, U.S. Nuclear Regulatory Commission.

2. Pasciak, W., E. F. Branagan, Jr., F. J. Congel, J. Fairobent, "A Method for Calculating Doses to the Population from Xe-133 Releases during the Three Mile Island Accident," Draft, September 1979, Radiological Assessment Branch, U.S. Nuclear Regulatory Commission.

3. Woodard, Keith, "Assessment of Offsite Radiation Doses from the Three Mile Island Unit 2 Accident," July 31, 1979, Report TDR-TMI-116, Pickard, Lowe, and Garrick, Consultants.

4. U.S. Nuclear Regulatory Commission, "Methods for Estimating Atmospheric Transport of Dispersion of Gaseous Effluents in Routine Releases from Light Water Cooled Reactors," July 1977, Regulatory Guide 1.111, Rev. 1, Office of Standards Development, Washington, D. C.

5. U.S. Nuclear Regulatory Commission," 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," October 1977, Regulatory Guide 1.109, Rev. 1, Office of Standards Development, Washington, D. C.

6. Bell, M. J., "ORIGEN-The ORNL Isotope Generation and Depletion Code," May 1973, Report ORNL-4628, Oak Ridge National Laboratory.

7. Hickey, Clarence, Jr., Robert B. Samworth, "The Non-Radiological Consequences to the Aquatic Biota and Fisheric of the Susquehanna River from the 1979 Accident at Three Mile Island Nuclear Station," Draft, August 1979, Report NUREG-0596, Environmental Specialists Branch, U.S. Nuclear Regulatory Commission, Washington, D. C.

8. Collins, John, William Travers, Ron Bellamy, "Report on Preliminary Radioactive Airborne Releases and Charcoal Efficiency Data: Three Mile Island Unit 2," United States Nuclear Regulatory Commission.

9. Memorandum from R. C. DeYoung, NRC, to W. Kreger, NRC, "Calculated Offsite Iodine-131 Air Concentrations from Three Mile Island," October 3, 1979.

10. Pasciak, Walt, Frank J. Congel, Edward F. Branagan, Jr., "Releases of Radionuclides into the Susquehanna River from Three Mile Island Nuclear Station during the Period of 3/28/79-5/11/79 - Data and Analysis," September 1979, Draft Report NUREG-0598, Radiological Assessment Branch, U.S. Nuclear Regulatory Commission, Washington, D. C.

11. Kreger, W. E. memorandum for Richard C. DeYoung, "Calculated Offsite I-131 Air Concentrations for the Three Mile Island Area Locations," dated October 25, 1979.

12. Hickey, C., NRC, personal communications with W. Pasciak, NRC on October 15, 1979.

13. Tasaka, Kanji, "Nuclear Data Library of Fission Products for Decay Power Calculations," May 1979, E.G.&G. Idaho, Inc., Idaho Falls, Idaho.

14. NBS Handbook No. 85, "Physical Aspects of Irradiation," March 1964, U.S. Government Printing Office, Washington, D. C.

15. Wang, Yen (Ed.), "Handbook of Radioactive Nuclides," 1969, Chemical Rubber Co., Cleveland, Ohio.

16. Dintz, Ira, NRC, personal communication with W. Pasciak on October 19, 1979.

17. K. Eckerman, ORNL, personal communication with W. Pasciak on October 22, 1979.

18. U.S. Nuclear Regulatory Commission, "Atmospheric Models for Potential Accident Consequence Assessments at Nuclear Power Plants, August 1979, Report Regulatory Guide 1.145, Washington, D. C.

19. Bursen, Zolin, E.G.&G., Inc., Las Vegas, Nev., personal communication with W. Pasciak on October 23, 1979.

20. 10 CFR 20, Appendix B, Table II.

21. Metropolitan Edison Company, Final Safety Analysis Report for Three Mile Island Nuclear Station, Unit No. 2.

APPENDIX F

REVIEW OF MEASURED RADIATION DOSES AND SURFACE CONTAMINATION MEASUREMENTS

December 1979

U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

SUMMARY OF RADIATION DOSE AND
SURFACE CONTAMINATION MEASUREMENTS

The results of radiation doses measured by TLD's located in the vicinity of the site indicate that the highest whole body radiation dose to a possible real individual was less than 0.1 rem to individuals located at the nearby residences on the East bank of the river. The maximum whole body dose that could have been received by a hypothetical individual was estimated to be approximately 1.4 rem for an individual located on the north northwest corner of Three Mile Island and less than 1.2 rem for an individual located on Kohr Island. In all three cases, no allowance has been made for reductions in actual radiation doses due to actual occupancy time (full time occupancy from 3/28/79 0400 to April 15, 1979* was assumed), the demonstrated over-response of the TLD's (which leads to measured values between 1.2 and 2.2 times greater the actual doses) or for shielding due to being indoors. The "could have been" hypothetical estimates include allowance for statistical measurement errors so that the probability of the stated value being exceeded is one chance in one thousand (99.9th percentile). More likely estimates of these doses, incorporating the energy overresponse corrections, would indicate that doses were less than 1 rem at both locations. Therefore, actual measurements indicate that the dose any individual could have received would be at least a factor of 10 lower than the Part 140 criterion of a 20-rem whole body dose. However, no one was at the location on Kohr Island or the location on Three Mile Island at the time of the accident.

An individual located on Hill Island could have received a dose of approximately 0.3 rem if he had remained continuously at this location throughout the period from 4:00 A.M. on March 28th until March 31st. However, actual occupancy times for this individual indicate that he departed before the persistent winds began blowing into the NW-NNW sectors on the night of March 28th when the majority of the dose at this location would have been delivered. The actual dose received is estimated to be less than 0.05 rem (50 millirem).

Surface contamination levels were assessed by a variety of measurement techniques, most of which were orders of magnitude more sensitive than the measurements called for in 10 CFR Part 140, Section 140.84(b). Except for one location on Three Mile Island, the only deposited radionuclide which was detected in concentrations greater than those measured in 1977 was iodine-131. Cesium 137 and cerium 144 were also detected in measurable amounts; however, the levels of

*Results of longer term measurements made by NRC, FDA, and the licensee show that noble gas whole body dose contributions after April 6, 1979 are negligible.

these radionuclides are consistent with 1977 measurements and are presumably due to residual fallout from atmospheric nuclear tests. The highest radioiodine concentration would have resulted in a dose rate of less than 0.2% of the 10 CFR Part 140 criterion of 4 millirads per hour (a factor of 600 less than the criterion). Cesium 137 and cerium 144 (and naturally occurring radionuclides) were also found in most soil samples, but at levels consistent with pre-accident levels as determined by 1977 soil analysis results. These radionuclides, in offsite samples, would have resulted in dose rates less than 0.02% of the Part 140 criterion of 4 millirad per hour.

One soil sample collected on Three Mile Island had levels of cesium-137, cesium 134, and cobalt 60 that were higher than those found elsewhere. This location had been reportedly used for low activity contaminated waste so that these levels are most likely from residual contamination rather than the accident. The combined dose rate from cesium 137, cesium 134, cobalt 60, and radioiodine 131 (found in an adjacent sample) would be 1.5 percent of the 4 millirem per hour (0.06 mR/hr) criterion. However, as this measurement was on licensee controlled land contiguous to the site, the 40 millirad per hour dose rate criterion would be applicable to this location. The estimated dose rate would be approximately 0.15 percent of (or a factor of 600 lower than) the 40 millirem/hour criterion.

In summary, environmental measurements do not support a finding that the criteria for substantial offsite doses or substantial releases of radioactive materials were or could have been met as a result of the accident on March 28, 1979 at the Three Mile Island Nuclear Station, Unit 2.

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A. RADIATION DOSE MEASUREMENTS USING THERMOLUMINESCENT DOSIMETERS

1. Description

The primary type of instrumentation that was relied upon for measuring radiation doses from the Three Mile Island Accident were thermoluminescent dosimeters (TLD's). These devices employ substances called phosphors that have the property of trapping or storing energy. The amount of energy that is trapped is proportional to the amount of radiation that is absorbed by the device. A single thermoluminescent dosimeter usually has several individual phosphors.

After exposure in the environment for a known period of time the TLD is taken back to a laboratory where it is heated under controlled conditions in a device called a "reader." The trapped energy in the TLD is released in the form of visible light by the heating process. The amount of light emitted is proportional to the initial radiation dose. The light is converted to an electrical signal by a photomultiplier tube and is recorded.

In order to convert the electronic signal into an estimate of radiation dose, it is necessary to know what the electronic signal is for a known dose of radiation. This is accomplished by exposing the TLD's to a source of radiation whose dose rate is known. By knowing the strength of the radiation source, the characteristics of the radiations emitted from the source, the distance from the source to the TLD, and the length of time that the TLD is exposed, it is possible to calculate the dose that the TLD should record. This can then be related to the magnitude of the electronic signal to determine the relationship between the electronic signal from the TLD reader and the radiation dose to the TLD. This process is called calibration. Once this relationship has been established for a particular type of TLD and a particular type of TLD reader, it can be used to determine the dose associated with the light output from TLD's that were exposed to unknown doses.

Thermoluminescent dosimeters have been used for several years to measure radiation doses. Under ideal conditions, it is possible to detect very low doses of radiation (down to 1 millirad) and to measure doses of the order of 10 millirad with considerable precision (± 10%). Their ability to measure such low doses combined with their small size and absence of any need for servicing while in use (except for periodic collection and replacement) are favorable for their application for environmental monitoring applications. Other favorable properties are a relatively low fading rate (typically, a few per cent of the absorbed energy lost per month) and a linear response to dose over a wide dose range (a few millirad to thousands of millirads).

The Nuclear Regulatory Commission has issued Regulatory Guides that define minimum acceptable performance criteria for TLDs used for environmental radiation measurements [(1)] and requirements for assuring the quality of environmental and effluent measurements[(2)].

(1) U.S. Nuclear Regulatory Commission, Regulatory Guide 4.13, Revision 1 "Performance, Testing, and Procedural Specifications for Thermoluminescense Dosimetry: Environmental Applications," July 1977.

(2) U.S. Nuclear Regulatory Commission, Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs (Normal Operations)-Effluent Streams and the Environment," December 1977.

A study of methods for thermoluminiscent dosimeter monitoring of nuclear power facilities also has been published by the NRC[3].

The specific types of TLDs that were in the vicinity of the Three Mile Island site have been described in the report of an Ad Hoc Interagency Group[4] and will not be described here.

2. Difference Between TLD Measurements of Dose and Survey Instrument Measurements of Dose Rate

It is important to distinguish "dose" from "dose rate." Dose rate is an instantaneous value of the rate of energy absorption. Dose is the total amount of energy absorbed, i.e., the integral (sum) of the dose rate over time. It is possible to have high dose rates, that last for only short periods of time, result in lower total doses than much lower dose rates which remain constant for longer periods of time. The TLD's measure dose, not dose rate. If the dose recorded by a TLD is divided by the length of time the TLD was exposed (left out in the field), it is possible to get an "average dose rate" over that period.

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(3) G. de Planque, "Evaluation of Methods for the Determination of X- and Gamma-Ray Exposure Attributable to a Nuclear Facility Using Environmental TLD Measurements," U.S. Nuclear Regulatory Commission contractor report NUREG/CR-0711, U.S. DOE Environmental Measurements Laboratory Report EML-355 (June 1979).

(4) EPA-HEW-NRC Ad Hoc Interagency Dose Assessment Group "Population Dose and Health Impact of the Accident at the Three Mile Island Nuclear Station-Preliminary Estimates for the Period March 28, 1979 through April 7, 1979" U.S. N.R.C. Report NUREG 0558 (May 1979).

Radiation survey instruments measure dose rate, not dose.* It would be possible for a survey instrument measurement to show an instantaneous dose rate that is considerably higher than the average dose rate calculated from a TLD at the same location, if this high dose rate lasted only for a short portion of the total period that the TLD was exposed. Although "dose" versus "dose rate" is the most significant difference between TLD and radiation survey meter measurements, there are other factors such as gamma energy response and sensitivity to beta radiation that affect the comparability of these two types of measurements.

3. Locations of Thermoluminescent Dosimeters

The TLD's that were initially employed were part of the environmental surveillance program for routine operation. Compliance with Appendix I (to 10 CFR Part 50) technical specifications and NRC dose limits (10 CFR Part 20) is based upon measured effluent releases together with dose computational models as specified in NRC

*An analogy to the relationship between dose rate and dose would be the relationship between the speed of an automobile (analogous to dose rate) and the distance the car traveled (analogous to dose). In order to measure the distance traveled (dose) from the instantaneous readings of the speed gauge (analogous to a survey meter), it would be necessary to know precisely for how long time the car traveled at each speed. The speed would vary considerably throughout a journey (for example, stopped at a traffic light compared to passing another vehicle) just as the dose rate at a particular location can vary with time. Neither the survey meter nor the automobile speed gauge provide a permanent record of their instantaneous readings. However, the total distance traveled may be read from the odometer and the total dose can be determined from a TLD. In both cases, an average value for the average speed or the average dose rate can be calculated by dividing the distance (or dose) by the duration or length of time passed. However, this average value is not comparable to any single instantaneous reading of the speed gauge or of a dose-rate survey meter. In the case of radiation exposure, the total dose delivered (analogous to distance) is more important than the value of any instantaneous dose rate reading.

Regulatory Guides 1.109, 1.111 and 1.113 (or equivalent models acceptable to the NRC staff). The limited number of thermoluminecent dosimeters that were in place prior to the accident were intended to confirm these calculated doses rather than providing primary measurements for compliance purposes.

Expected maximum annual doses from noble gases from normal operation are less than 1 millirem.* These maximum doses would be expected to occur at a location in the immediate vicinty of the site, therefore, most of the thermoluminescent dosimeters were located within 2 miles of the site, except for 5 "background" stations located beyond this distance. The number of TLD stations was in conformance with license technical specifications for Three Mile Island Unit No. 1 and Unit No. 2.

Figure A-1 shows the locations of the close-in TLD monitoring sites that were part of the routine environmental radiation surveillance program conducted by the Metropolitan Edison Company and required by NRC. Table A-1 shows the locations of all 20 Metropolitan Edison TLD monitoring sites. The primary environmental monitoring TLD's and related services were furnished under contract to Metropolitan Edison by Teledyne-Isotopes, Inc.

*The pre-operational estimates of the annual whole body dose to maximally exposed individual due to noble gas releases from routine operation of Three Mile Island Unit No. 2 was 0.3 millirem. Final Supplement to the Final Environmental Statement related to the operation of Three Mile Island Nuclear Station, Unit 2. U.S. NRC Report NUREG-0112 (Docket No. 50-320), December 1976. Table 5-4.

ON ISLAND (GE SERIES) SURVEY POINTS

AND NEAR-FIELD TLD LOCATIONS

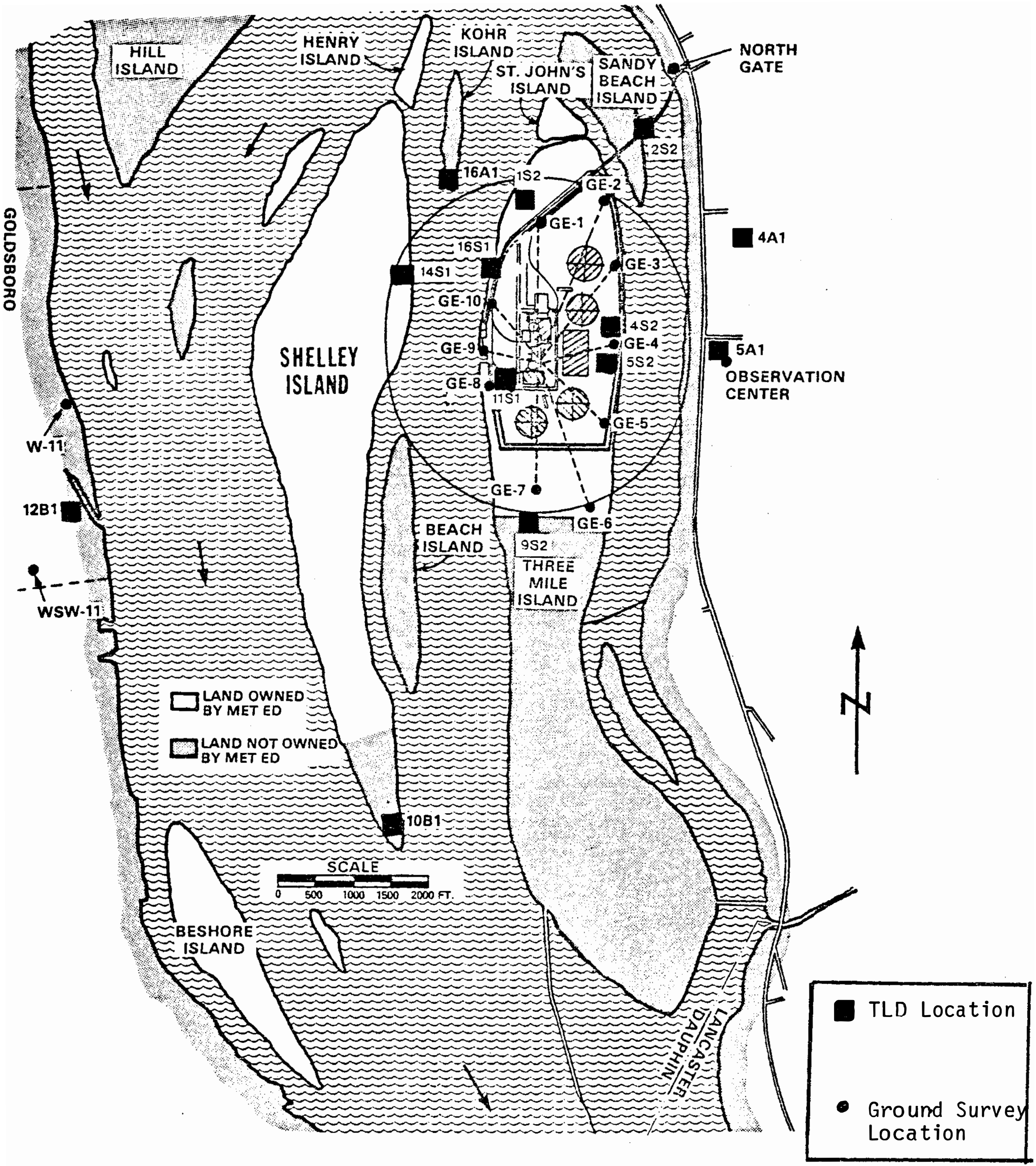

Figure A-1 Location of Thermoluminescent Dosimeters (TLD) in the Vicinity of Three Mile Island

At 10 of the 20 locations, a second set of thermoluminescent dosimeters, furnished by the Radiation Management Corporation (RMC), were also in place. These dosimeters provided a check (quality assurance) on the primary (Teledyne-Isotopes) TLD's. The RMC dosimeters were of a different design than the Teledyne-Isotopes TLD's and used a different phosphor matrix (see reference 4 for a description). In addition to the quality assurance TLD's (which are denoted by a "Q" following the site designation or a "+Q" in Table A-1), there were also replicate Teledyne-Isotopes TLD's in place at several sites. These replicates are denoted by "+R" in Table A-1.

Except for the three sites on the nearby islands, all of these TLD's had been in place starting from December 27, 1978. The three sites on Kohr Island and Shelley Island (16A1, 14S1, and 10B1) are generally not accessible in the winter months. The TLD's at these three sites were initially placed on September 27, 1978 and were not replaced in December 1978. All of these TLD's were in place prior to and during the initial phases of the accident. They were replaced on March 29, 1979, the day following the start of the accident, and at three day intervals thereafter throughout the month of April.

In addition to the Teledyne-Isotopes and RMC TLD's, the Metropolitan Edison Company also deployed Harshaw personnel dosimeters (TLD's worn by plant workers) at 11 sites around the fenceline of the plant. These dosimeters were of a different type than either of the other two types of TLD's. The

TABLE A-1 THERMOLUMINESCENT DOSIMETERS PLACED BY METROPOLITAN EDISON IN THE VICINITY OF THE THREE MILE ISLAND SITE (Dosimeters were in place starting on 12/27/78) (except for * which remained in place starting from 9/27/78)

SECTOR	0-2 MILES STATION	0-2 MILES DISTANCE (Miles)	2-5 MILES STATION	2-5 MILES DISTANCE (Miles)	5-10 MILES STATION	5-10 MILES DISTANCE (Miles)	GREATER THAN 10 MILES STATION	GREATER THAN 10 MILES DISTANCE (Miles)	TOTAL NUMBER OF SITES	NUMBER OF TLD's MON.[a]	REPL.[b]	QA[c]	TOTAL
1. N	1S2.(+Q)	0.4	1C1	2.6					2	2	0	1	3
2. NNE	2S2	0.7							1	1	0	0	1
3. NE									0	0	0	0	0
4. ENE	4S2 (+Q) 4A1	0.3 0.5			4G1 (+Q)	10			3	3	0	2	5
5. E	5S2 (+Q) 5A1 (+Q,2R)	0.2 0.4							2	2	2[d]	2	6
6. ESE									0	0	0	0	0
7. SE					7F1(+Q)	9	7G1	15	2	2	0	1	3
8. SSE			8C1(+Q)	2.3					1	1	0	1	2
9. S	9S2	0.4					9G1	13	2	2	0	0	2
10. SSW	10B1*(+R)	1.1							1	1	1[e]	0	2[e]
11. SW	11S1(+Q)	0.1							1	1	0	1	2
12. WSW	12B1	1.6							1	1	0	0	1
13. W									0	0	0	0	0
14. WNW	14S1*(+R)	0.4							1	1	1[e]	0	2[e]
15. NW							15G1(+Q)	15	1	1	0	1	2
16. NNW	16S1 (+Q) 16A1 (+R)	0.2 0.4							2	2	1[e]	1	4
Sub-Total	Sites	13		2		2		3	20	20	5	10	35
	TLD's	24[e]		3		4		4					

Footnotes:
(a) Primary environmental monitoring TLDS (Teledyne-Isotopes)
(b) Replicate Teledyne-Isotopes TLD's (R)
(c) Quality Assurance badges (+Q) (Radiation Management Corporation)
(d) Replicate Teledyne badges in place 3/29/79-3/31/79 only
(e) Replicate Teledyne badges in place 9/27/78-3/29/79

TABLE A-2 THERMOLUMINESCENT DOSIMETERS PLACED BY THE NUCLEAR REGULATORY COMMISSION STAFF IN THE VICINITY OF THE THREE MILE ISLAND SITE (Dosimeters were in place starting on 3/31/79)

SECTOR	0-2 MILES		2-5 MILES		5-10 MILES		GREATER THAN 10 MILES		TOTAL NUMBER OF SITES
	STATION	DISTANCE (Miles)	STATION	DISTANCE (Miles)	STATION	DISTANCE (Miles)	STATION	DISTANCE (Miles)	
1. N			N-1	2.6	N-2 N-3 N-4	5.1 7.4 9.3	N-5	12.6	5
2. NNE	NE-1 NE-2	0.8 1.8	NE-3	3.1					3
3. NE					NE-4	6.7			1
4. ENE	E-1	0.5							1
5. E	E-5(E-1a)	0.4	E-3	3.9	E-4	7.0			3
6. ESE			E-2	2.7					1
7. SE			SE-4	4.6	SE-5	7.0			2
8. SSE	SE-1	1.0	SE-3	2.3					3
9. S			S-1	3.2	S-2 S-3	5.3 9.0	S-4	12	4
10. SSW			SW-1	2.2					2
11. SW					SW-3	8.3	SW-4	10.4	2
12. WSW	W-2	1.3							1
13. W	W-1	1.3	W-3	2.9	W-4 W-5	5.9 7.4			4
14. WNW			NW-1	2.6	NW-3	7.4			2
15. NW					NW-2 NW-4	5.9 9.6	NW-5	13.8	3
16. NNW									0
Totals									
Number of TLDS	8		11		14		4		37
Number of Sectors	6		10		9		4		15

Pennsylvania Department of Environmental Resources (Bureau of Radiation Protection) deployed two sets of dosimeters at 4 of the Metropolitan Edison Company monitoring sites (IC1, 5A1, 8C1, and 12B1) to provide an independent verification of the monitoring results. These four sites had one TLD provided to the State by the Radiation Management Corporation and a second TLD furnished by the Department of Energy's Radiological and Environmental Sciences Laboratory in Idaho under contract to the Nuclear Regulatory Commission. These TLD's were also in place prior to the start of the accident.

On March 31, 1979, three days after the start of the accident, the Nuclear Regulatory Commission staff placed TLD additional dosimeters at 37 locations (Table A-2). These dosimeters were also furnished by the Radiation Management Corporation (RMC), but were different types than the RMC TLD badges used for quality assurance of the primary environmental monitoring (Teledyne-Isotopes) TLD's. A few of these dosimeters (Type UD-801) have an "open window" (no filtration) to minimize attenuation of beta radiation. These TLDs could detect beta radiation. The other RMC or Teledyne-Isotopes TLD's have filters over the phosphors that would block most beta radiation and would not detect beta radiation. The NRC dosimeters were collected and readout daily. On April 1, 1979 the NRC staff placed two additional TLDs at each of these locations. This second set of TLD's was left in place until May 1, 1979. Third set of NRC (RMC) dosimeters was placed at 10 schools on April 5, 1979 and were replaced daily. The locations of these NRC

TLD's are described in the report of the Ad Hoc Interagency Dose Assessment Group (4).

4. Factors Affecting Uncertainties in Doses Measured by Thermoluminescent Dosimeters

a. Spatial Distribution

One of the principal sources of uncertainty in the estimates of population dose is the fact that TLD measurements were made at only 20 locations. Three of the 16 compass directions (northeast, east-southeast, and west) did not have any TLDs and in two additional sectors (northwest and southeast) the TLDs that were closest to the site were at 15 miles (NW) and 9 miles (SE). Because of the small number of TLD monitoring locations, an hour-by-hour analysis was made of the wind direction and TLD locations (Annex 1). The results of this analysis are summarized in Table A-3.

As noted in the preceding section, the thermoluminescent dosimeters that were deployed as part of the licensee's environmental surveillance program were primarily located near the Three Mile Island site. This is reflected in Table A-3 which shows that the area within 2 miles was monitored with a greater frequency then outlying areas. Even at the closer distance there were sectors unmonitored by TLD's for a significant portion of the time between the initiation of the accident (approximately 4:00 a.m. on March 28th) and April 1st. For 13 hours of the 37 unmonitored hours in the initial period, the wind blew in a direction where there were no known inhabitants

TABLE A-3 APPROXIMATE ESTIMATES OF GEOGRAPHIC COVERAGE BY THERMOLUMINESCENT DOSIMETERS DEPLOYED IN THE VICINITY OF THE THREE MILE ISLAND NUCLEAR STATION

	0400 MARCH 28, 1979 THRU 2400 MARCH 31, 1979					0400 MARCH 28, 1979 THRU 1800 APRIL 6, 1979				
PERIOD DISTANCE	0-2 Miles	2-5 Miles	5-10 Miles	> 10 Miles	ANY DISTANCE	0-2 Miles	2-5 Miles	5-10 Miles	> 10 Miles	ANY DISTANCE
Hours wind blew into sector with TLD's within indicated distances										
Metropolitan Edison TLD's	56	10	11	12	73	136	28	25	28	183
Added hours from NRC TLD's	0	2	5	4	4	23	86	78	22	27
Total Hours in monitored areas	56	12	16	12	77	159	114	103	50	210
Total Hours in unmonitored areas	37	81	77	81	16	67	112	123	123	16
Total Hours in Period	93	93	93	93	93	226	226	226	226	226
Percentage of total time										
Area was monitored by TLD's	60	14	17	13	83	70	50	46	22	93
Areas unmonitored by TLD's	40	87	83	87	17	30	50	54	78	7

Note that extensive numbers of TLDs were also placed by the Bureau of Radiological Health, FDA on March 31st. These TLDs are not reflected in this table and would reduce the unmonitored times considerably beyond March 31st.

within 2 miles (NW sector for 8 hours) or where reasonable extrapolations of doses can be made from TLD's just beyond this distance (SSE sector at 2.3 miles). Therefore, the principal time period of interest can be considered to be 24 hours. If the TLDs had been the only form of offsite monitoring this would have been a substantial time period for these offsite areas to have been unmonitored. However, the TLD's were not the only form of monitoring being undertaken. Table A-4 provides an abbreviated chronology of significant monitoring activities. The combination of on site, offsite, and aerial surveys supplements the TLDs and provides reasonable assurance that significant releases did not go unmonitored. The highest measured dose rates are also summarized in this table, but these readings are not representative at all of the dose rate measurements made. The NRC report referenced in this table provides a more complete summary of these measurements.

b. Background Radiation

In addition to registering the dose from certain radioactive materials released from a nuclear facility, TLD's also absorb radiation from naturally occurring radioactive materials such as traces of uranium, thorium and their daughter products (e.g., radium and radon) and potassium-40 in soil and rocks, from cosmic radiation bombarding the earth, and from other sources such as residual contamination from atmospheric nuclear testing. Radiation from these sources constitutes a "background" dose level which must be estimated in order to evaluate the dose contribution from the nuclear facility.

Table A-4-Abbreviated Chronology of Radiation Monitoring Activities and Significant Radiation Measurements

(Based upon NRC Office of Inspection and Enforcement Report NUREG-0600, "Investigation into the March 28, 1979 Three Mile Island Accident by the Office of Inspection and Enforcement," Investigative Report No. 50-320/79-10, Appendix II-A and Section 3.3.3.1.)

<u>March 28, 1979</u>

0730	Metropolitan Edison survey team dispatched to west side of island begins monitoring at 0748 finding exposure rate to be less than 1 mR/hour.
0730	Metropolitan Edison survey team dispatched to Goldsboro begins monitoring at 0832 and found no detectable increase (above background) in radiation levels (less than 1 mR/hr).
0830	A second metropolitan Edison survey team was dispatched to Goldsboro.
0900	An air sample taken in Goldsboro showed no radioiodine (less than the minimum detectable levels of 5×10^{-9} µCi/cc)
0922	Air sample in Goldsboro indicates radioiodine concentration to be 10^{-8} µCi/cc approximately 100 times higher than 10 CFR Part 20 limits (10^{-10} µCi/cc) for continuous annual exposure. Sample at 0950 is 1.2×10^{-8} µCi/cc. However, laboratory analysis (Pennsylvania Bureau of Radiological Health) shows air concentrations to be less than 1.5×10^{-11} µCi/cc or 0.15 of 10 CFR Part 20 limits . The high readings were due to noble gases not radioiodine.
1010	NRC inspectors from Region I (King of Prussia) arrive on site.
1020	Onsite (and offsite) radiation levels begin to increase.
1100-1130	NRC inspectors begin monitoring radiation levels onsite and in the environment.
1415	Department of Energy Serial Monitoring System Aircraft arrives and begins aerial radiation surveys.
1548	50 mR/hr exposure rate measured along Route 441 on East bank.
1930	NRC Region I Mobile Laboratory arrives from Connecticut.
2130	"Open window" reading of 300 mR/hr measured near north warehouse.

2325 "Open window" radiation exposure level of 365 mR/hr (50 mR/hr closed window) is detected at the northwest corner of Three Mile Island (monitoring site GE-10). This is the highest reported onsite (ground level) dose measurement made outside of the reactor buildings.

March 29, 1979

0600 30 mR/hr (open window) exposure rate measured at Goldsboro.

1410 Helicopter measures 3 R/hr (3,000 mR/hr) "Open-window" (400 mR/hr "closed-window") exposure rate 15 feet above stack.

March 30, 1979

0756-0801 Radiation levels measured 130 feet above Unit 2 auxilliary building are 1,000 - 1,200 mR/hr ("open window").

This "background" dose varies with location as a result of differences in local mineral composition and with time due to changes in solar activity and weather conditions (air pressure, rainfall and snow cover). These variations introduce some uncertainty into estimates of the dose from nuclear reactor emissions as the "background" dose contribution must be inferred from either TLD's remote from the nuclear facility or from pre-operational data for a given location. For the purpose of evaluating the dose contribution from the accident, TLD's readings from comparable periods in 1978 were used. Although these readings may have contributions from the routine operation of TMI Unit 1, these contributions are small (if not negligible) compared to both the accident dose contribution and the natural background dose for the period preceding the accident (either December 27, 1978 or September 27, 1978 through March 27, 1979). As the weather and other conditions are not exactly comparable for the period of this "background" dose measurement in 1978 and the periods of interest in 1979, some degree of uncertainty is introduced in determining the appropriate "background" dose for subtracting from the total dose recorded by the TLD's. This uncertainty is more important for the lower doses measured away from the reactor facility than for the TLD locations adjacent to the site as the "background" dose (and, therefore, any uncertainty in it) is a greater fraction of the total recorded dose at the more distant locations.

In addition to the "background" dose contribution recorded at the TLD location, there is also another type of "background" dose, the "transit dose." This "transit dose" is the additional dose recorded by the TLD's from the time that they are re-zeroed (annealed) until they are placed out in the field at their measuring location and from the time they are collected until they are "read-out" in the laboratory. Generally, this "transit dose" contribution is accounted for by carrying TLD's during the period of set out and pick up that are read out after these operations are completed. This "transit dose" determination was not performed properly for the NRC TLD's placed on March 31, 1979 and these TLD's were stored for several hours at the NRC trailer within a half-mile of TMI.* The transit dose contributions are also significant for the NRC TLD's placed after March 31st as they were collected daily. However, corrections were applied to the later results. Problems with the daily NRC TLD's were noted in the Ad Hoc Interagency Group report and in the draft report of The Task Group on Health Physics and Dosimetry of The President's Commission on the accident at Three Mile Island. NRC TLD's placed on April 1, 1979 and collected on May 1, 1979 are believed to reflect more accurately the doses for this period than would a summation of the daily TLD readings for the same period.

*The Presidential Commission's Task Group on Health Physics and Dosimetry rejected the results of the March 31st NRC TLD's for this reason.

c. Energy Dependence

The materials that are used in the TLD phosphors absorb energy to a different extent at different gamma ray energies. They absorb more energy from low energy gamma radiation than from higher energy gamma radiation. This, in turn, leads to higher doses being registered at low energies than actually exist in tissue or air. The TLD badges contain thin metallic plates (filters) which absorb some of the lower energy gamma radiation. These filters result in a more uniform response of the TLD's to different gamma radiation energies and therefore, make the doses recorded by the TLD's more equivalent to doses in tissue or in air.

Xenon-133, one of the principal products of uranium fission, is a radioactive gas which has a relatively low energy gamma radiation energy (81 kiloelectron volts, kev). It also emits a 37 kev X-ray.* Xenon-133 was identified as one of the principal radionuclides released to the environment as a result of the Three Mile Island accident. Because of this low energy gamma emission, the energy dependence of the TLD's was examined by the Ad Hoc Interagency Dose Assessment Group and by the Task Group on Health Physics and Dosimetry of the President's Commission on the Accident at Three Mile Island.

*The principal difference between gamma radiation and X-rays is that gamma radiation is emitted from the nucleus of an atom while X-rays originate from the electrons surrounding the nucleus.

The Ad Hoc Task Group requested that NRC's Office of Inspection and Enforcement (IE) obtain samples of the TLD's used for environmental monitoring and determine their response to a known quantity of xenon-133. The National Bureau of Standards subsequently performed this calibration under an existing agreement with NRC (IE). The TLD's were exposed to both the gamma radiation from an external calibrated source of xenon-133 and to the combined beta and gamma radiation from submersion in a known volume of xenon-133. The dose from the external exposure was measured with ionizing chambers and this measured dose (107 mR) shows good agreement with the calculated exposure (104 mR). The results of this experiment are shown in Table A-5. The doses received by the TLD's in the submersion experiment could not be determined due to xenon-133 leakage through the plastic weather-proof packaging. The xenon gas remained in unknown amounts in the package when the exposure chamber was evacuated and continued to irradiate the TLD's past the time of intended exposure.

The Task Group on Health Physics and Dosimetry of the Presidential investigation performed a more thorough analysis of the Teledyne-Isotopes TLD energy response. They found that the response to xenon-133 gamma radiation was highly dependent upon the angle between the incident radiation and the TLD as shown in Table A-6.

TABLE A-5 RESPONSE OF THE THERMOLUMINESCENT DOSIMETERS TO XENON-133 RADIATION FROM AN EXTERNAL SOURCE

Calculated Exposure	104 mR
Measured Dose (ionization chamber measurements)	107 mR±15%

Dosimeter type	Reported Reading mR	Response (assuming true value is 107 mR)	Possible Range (91-128 mR)
Radiation Management Corp.			
Type UD-801 (beta) (NRC)	86	-20%	-30% to -5.5%
Type UD-804 (environmental) (NRC)	80	-25%	-35% to -12%
Type UD-200S (glass) (used by Metropolitan Edison for quality control)	137	+28%	+11% to +50%
Teledyne-Isotopes (used by Metropolitan Edison for environmental radiation surveillance)	84	-21%	-32 to -7.7%

TABLE A-6 ANGULAR RESPONSE OF TELEDYNE-ISOTOPES, INC. TLD TO XENON-133

Determined by the Task Group on Health Physics and Dosimetry of the President's Commission on the Accident at Three Mile Island

Angle of Incidence	Relative Response to Measured Dose Rate
0° (straight-on)	0.91
30°	0.83
45°	0.88
60°	1.50
90° (from side)	3.62

These results indicate that, although the response to xenon-133 was likely to underestimate (by 10-20%) the dose at low angles of incidence (similar to the angles of incidence used in the NBS experiment), the TLD response to a cloud of xenon-133 which irradiates from all directions (similar to the actual field exposure conditions during the accident) is likely to overestimate doses.

The NBS calibration results would indicate that the Teledyne TLD's should read less than the Radiation Management Corp. TLD's by a ratio of 0.84/1.37 = 0.63. However, in Table A-7 the ratio of the actual accident TLD readings consistently showed that the Teledyne TLD's read higher doses than the RMC badges indicating an overresponse.

The Teledyne TLD readings were used by The Ad Hoc Task Group for estimating individual and population doses. The Ad Hoc results would, therefore, have overestimated these doses as they were not corrected for the energy response of the TLD's. This energy response correction was taken to be 1.2 for 12/27/78 - 3/29/79 and 1.5 for subsequent periods by the Presidental Task Group. The energy dependence corrections are the primary reason for the lower population dose estimate made by The Presidential Task Group (2800 person-rem compared to the Ad Hoc Task Group's mean estimate of 3300 person-rem). The overresponse corrections are predicated upon the RMC TLD readings being energy independent. If the RMC TLD's over-respond by a factor of 1.34 (as indicated by the NBS experiment), the Teledyne TLD's would overrespond by factors between (1.6 - 2.0). Measurements performed at the University of Michigan using X-rays suggest that the Teledyne TLD overresponse to xenon-133 radiation (80 kev) is somewhat greater than a factor of 2. This means that the actual doses might be half of the doses reported by the Ad Hoc Task Group.

Table A-7

MEASURED RATIO OF READINGS OF TELEDYNE TLD/RMC TLD
(WHERE BOTH MEASUREMENTS ARE AT LEAST 5 mR AND
MORE THAN TWO STANDARD DEVIATIONS ABOVE BACKGROUND)

Period	12/27/78- 3/29/79	3/29/79- 3/31/79	3/31/79- 4/3/79	4/3/79- 4/6/79
Ratio (±S.E.)	1.19±0.05	1.44±0.05	1.32±0.15	1.56±0.12
number of TLDs	5	8	5	3

d. Precision of Measurements

The precision of a set of measurements is an indication of the spread between the individual values.* As there were several locations that had more than one TLD, the agreement between replicate measurements can be analyzed. Figure A-2 shows a plot of the readings of paired Teledyne-Isotopes TLD's. Most of these values are from pairs of TLD's that were located on islands adjacent to Three Mile Island for the period 9/27/78 through 3/29/79. There is good agreement between duplicate readings except for the two TLD's located on Kohr Island. One of these TLD's had a "net" (background and transit doses subtracted) of 902 mR and the second TLD read 447 mR. The reason for this discrepancy has not been determined, despite investigations by NRC (Region I) and the Task Group on Health Physics and Dosimetry of the Presidential investigation. One possible explanation for the discrepancy is that one TLD (the higher reading) happened to be located in front of the other (the lower reading), partially shielding it. This discrepancy is unusual in that paired TLD having much lower dose readings showed better agreement (the statistical differences should increase at lower doses).

Figure A-3 is a plot of the readings of the Teledyne TLD's versus the readings of the RMC quality assurance TLD readings at the same site. As can be seen from the plot, the agreement

*Precision is different from accuracy. Accuracy refers to how close the measured value is to the true value.

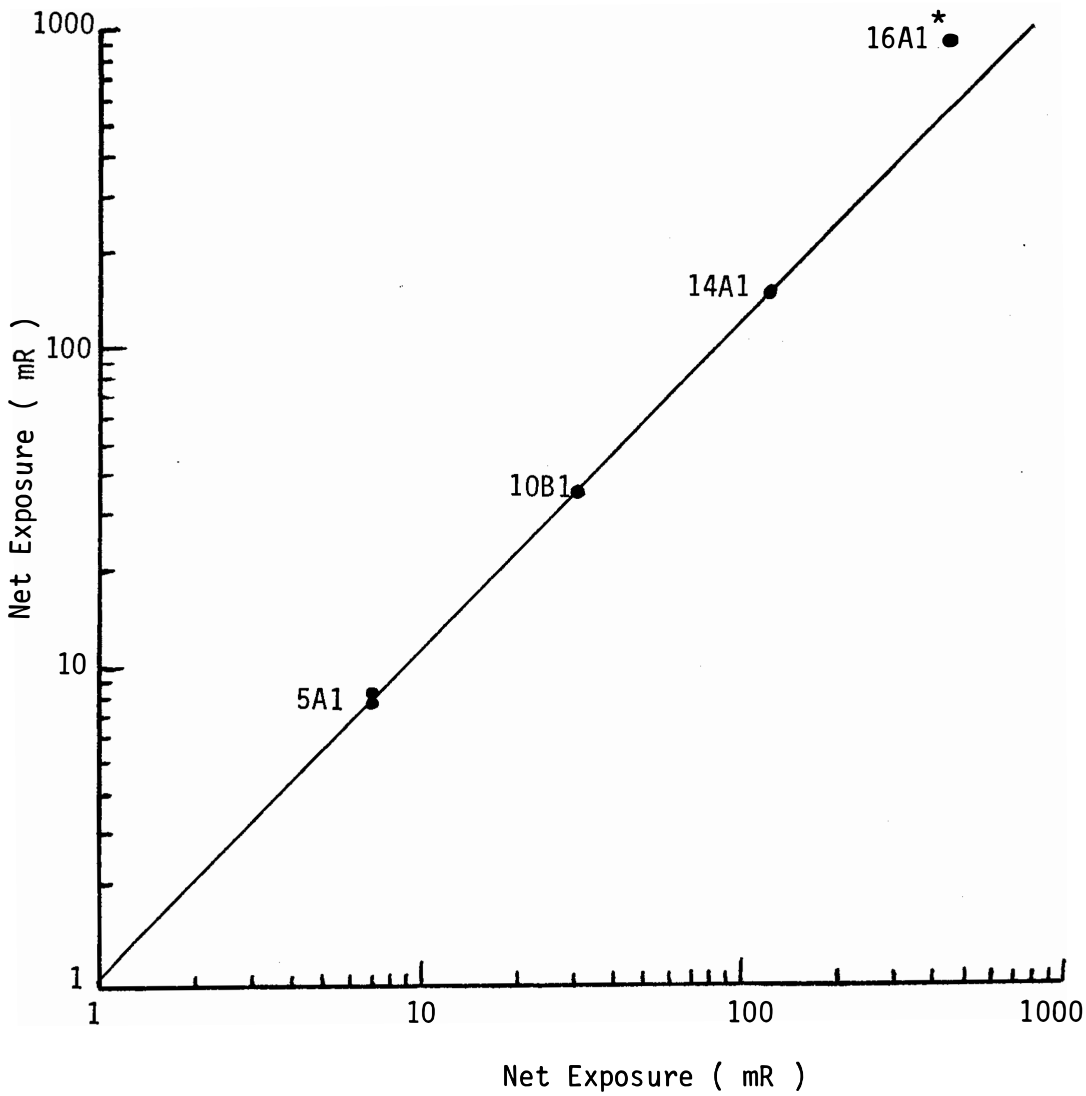

Figure A-2 Log-log plot of replicate Teledyne-Isotopes Thermoluminescent Dosimeter readings. The point labeled 16A1* (Kohr Island) was omitted from the regression analysis. The log-log regression fit was $Y = 1.061\ x^{1.016}$.

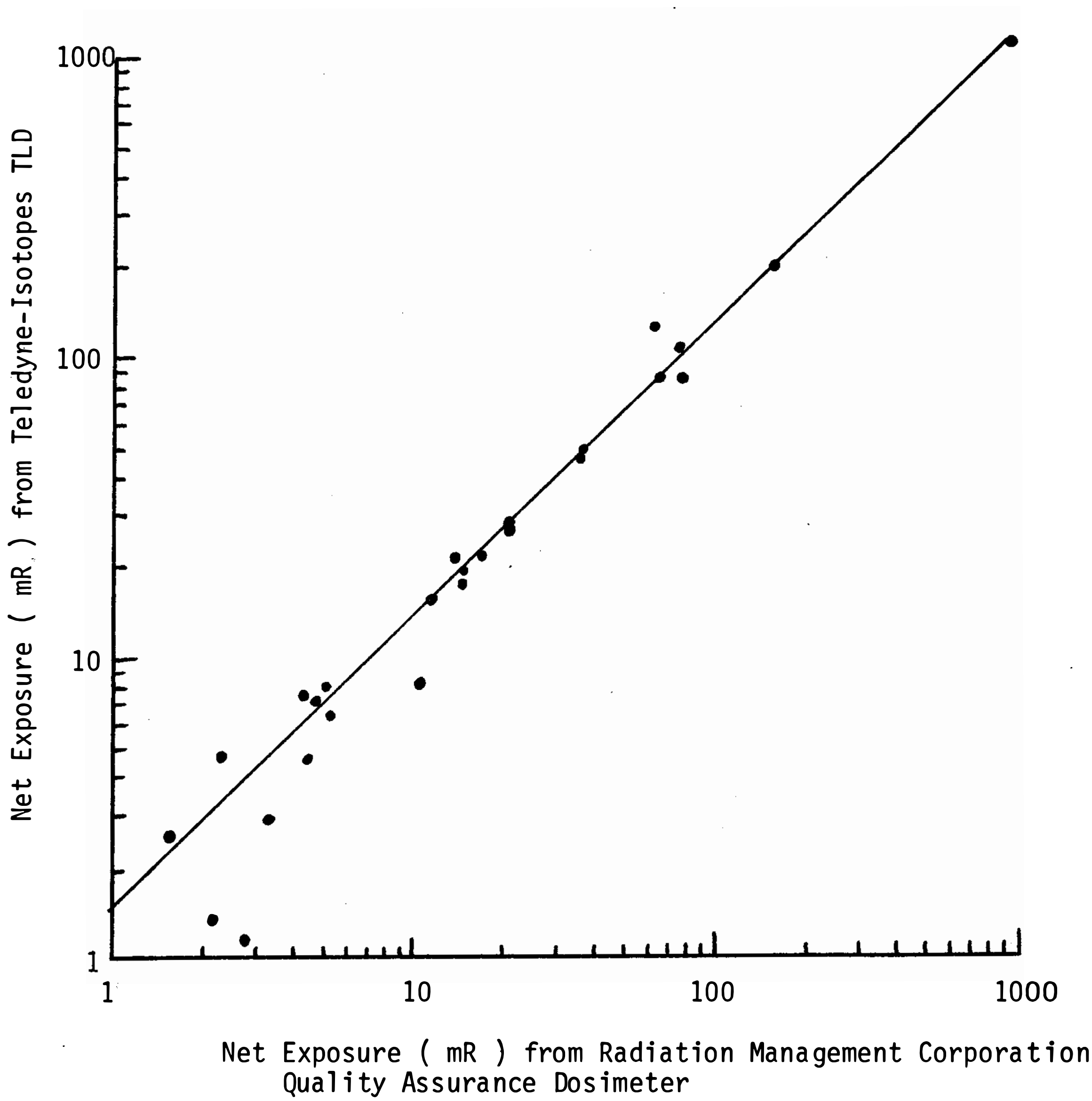

Figure A-3. Comparison of Paired Teledyne-Isotopes, Inc. and Radiation Management Corporation Thermoluminescent Dosimeters at the same location. The log-log regression equation for points having both readings greater than 5 mR is $Y(\text{Teledyne}) = 1.428\ X(\text{RMC})^{0.978}$.

is as expected, better at higher dose levels than at the very low doses. The statistical fluctuation at low doses is greater and is a determinant of the lower limit of detection which is stated to be 0.5 mR for the Teledyne-Isotopes TLD's and RMC TLD's used for quality assurance. A correlation of the readings of paired RMC and Teledyne-Isotopes TLD's showed that the average ratio of Teledyne-Isotopes to RMC readings when both sets of TLD's had net doses above 5 mR was 1.43, further confirms that the Teledyne-Isotopes TLD "overresponded," or read higher than the actual dose.

5. Results

The results of the TLD readings for the close-in TLD locations (where the highest doses from external gamma radiation would be expected) for the first week following the accident are shown in Table A-8. The principal dose contributions can be seen to occur in the period prior to April 3rd. This is confirmed by the ground surveys and also by the results of longer-term measurements by NRC TLD's (Table A-9) by TLD's placed by the Food and Drug Administration's Bureau of Radiological Health staff. The highest readings during the period from approximately April 1 through May 11 show that the measured dose contribution at any location is around 15 mR for this period.

The highest doses recorded by thermoluminescent dosimeters were at locations in the north-northwest sector at locations 16S1 and 16A1 (Kohr Island). Taking the higher reading at Kohr Island for the

TABLE A-8 THERMOLUMINESCENT DOSIMETER READINGS FOR "CLOSE-IN" STATIONS FOR THE FIRST WEEK FOLLOWING THE ACCIDENT

		NET EXPOSURE (mR) ± 1 STANDARD DEVIATION				
SECTOR	STATION	3/28[a]-3/29	3/29-3/31	3/31-4/3	4/3-4/6	TOTAL 3/28-4/6
1. N	1S2	83.8±1.94	19.7±3.4	-0.56[b]±0.10	0.14±0.10	103±3.9
	1S2Q*	78.4±5.10	14.9±3.2	0.74±0.10	0.24±0.10	94.3±6.0
2. NNE	2S2	31.4±4.42	32.2±5.6	3.00±0.60	0.50±0.20	67.1±7.2
3. NE	-	-	-	-	-	-
4. ENE	4S2	21.0±4.3	124±32.7	27.5±9.1	7.43±2.3	180±34.3
	4S2Q*	16.5±2.1	71.0±13.0	20.8±6.6	4.22±0.40	113±14.7
	4A1	6.28±1.43	34.0±8.6	41.0±8.5	1.75±0.40	87.1±12.2
5. E	5S2	17.5±1.36	49.0±11.2	26.3±5.3	15.1±5.0	107.9±13.4
	5S2Q*	14.6±4.05	36.3±0.8	20.7±3.1	11.1±2.4	82.8±5.7
	5A1	4.68±1.12	8.00±2.8	7.25±2.5	2.55±1.2	22.5±4.1
	5A1Q*	2.27±1.39	5.10±1.0	4.75±0.9	1.55±0.60	30.4±2.0
6. ESE	-	-	-	-	-	-
7. SE	-	-	-	-	-	-
8. SSE	8C1	2.41±0.76	10.5±1.6	1.35±1.1	0.95±0.40	15.2±2.1
	8C1Q*	-1.2[b]±1.91	8.12±1.0	2.15±0.2	0.65±0.10	9.7±2.2
9. S	9S2	10.87±3.0	25.0±2.6	4.14±1.0	1.34±0.3	41.4±4.1
10. SSW	10B1	34.7±3.6	14.77±0.9	0.20±0.30	0.90±0.20	50.6±3.7
		30.6±1.4				46.5±1.7
11. SW	11S1	200.6±24.1	106.8±12.7	44.5±15.2	21.3±7.3	373±32.0
	11S1Q*	152.3±15.6	75.3±12.7	34.7±3.3	13.7±1.1	276±20.4
12. WSW	12B1	5.50±0.92	9.16±1.6	-0.15[b]±0.30	0.85±0.20	17.2±1.9
13. W	-	-	-	-	-	-
14. WNW	14S1	125±20.6	48.7±8.6	9.28±4.3	1.28±0.40	183.8±22.7
		142±9.7				201±13.7

TABLE A-8 CONTINUED

SECTOR	STATION	NET EXPOSURE (mR) ± 1 STANDARD DEVIATION 3/28[a]-3/29	3/29-3/31	3/31-4/3	4/3-4/6	TOTAL 3/28-4/6
15. NW	-	-	-	-	-	-
16. NNW	16S1	1025±128	83.3±17.5	6.37±0.70	0.87±0.30	1115±129
	16S1Q*	912.5±90.5	61.3±12.2	5.21±1.0	0.91±0.50	978±91.4
	16A1	902±49.4	45.0±2.1	1.50±1.1	0.70±0.10	949±49.4
		447±12.2				494±12.4

*The "Q" denotes quality assurance TLD's furnished by the Radiation Management Corporation.

(a)The dosimeters were actually in place from 12/27/79 except for stations 10B1, 14S1, and 16A1 which were in place from 9/28/78.

(b)The negative readings result from the subtraction of transit doses and estimate background doses and result from statistical variations in these data.

TABLE A-9 RESULTS OF NRC DOSIMETERS EXPOSED
APRIL 1, 1979 THROUGH MAY 1, 1979
AND APRIL 5, 1979 THROUGH MAY 3, 1979(*)

Sector	Station No.	Distance	Direction	Gross Reading[(a)] mR	Location
N	N-1a*	2.4 mi	356°	5.2±0.5*	
	N-1	2.6 mi	358°	missing	Middletown
	N-1c*	3.0 mi	0°	missing*	
	N-1e*	3.5 mi	349°	5.0±0.3*	
	N-1f*	4.0 mi	351°	5.0±0.3*	
	N-2	5.1 mi	0°	5.2±0.3	Clifton
	N-3	7.4 mi	6°	5.5±0.3	Hummelstown
	N-4	9.3 mi	0°	5.6±0.2	Union Deposit
	N-5	12.6 mi	3°	5.6±0.2	
NNE	NE-1	0.8 mi	25°	4.9±0.5	North Gate
	NE-2	1.8 mi	19°	4.9±0.5	Geyers Ch.
	NE-3	3.1 mi	17°	5.7±0.3	Township School
NE	NE-3a*	3.6 mi	44°	4.9±0.4*	
	NE-4	6.7 mi	47°	5.5±0.3	
ENE	E-1	0.5 mi	61°	8.2±0.9	
	E-5(E-1a)	0.4 mi	90°	7.9±1.1	
	E-3	3.9 mi	94°	6.7±0.4	Newville
	E-4	7.0 mi	94°	5.9±0.5	Elizabethtown
ESE	E-2	2.7 mi	110°	5.3±0.5	
SE	SE-4	4.6 mi	137°	7.7±1.2	Highway 441
	SE-4a*	5.0 mi	146°	5.0±0.4*	
	SE-5	7.0 mi	135°	5.7±0.5	Bainbridge
SSE	SE-1	1.0 mi	151°	15.7±2.5	
	SE-2	1.9 mi	162°	8.9±1.0	Falmouth
	SE-3	2.3 mi	160°	7.6±1.3	Falmouth
S	S-1	3.2 mi	169°	7.3±0.7	York Haven
	S-1a*	3.35 mi	173°	5.0±0.4*	
	S-2	5.3 mi	178°	5.9±0.5	Conewago Heights
	S-3	9.0 mi	181°	7.6±0.3	Emigsville
	S-4	12.0 mi	184°	6.3±0.4	Woodland View
SSW	SW-1	2.2 mi	200°	6.1±0.6	Bashore Island
	SW-2	2.6 mi	203°	7.8±0.6	Pleasant Grove
SW	SW-3	8.3 mi	225°	5.9±0.4	Zions View
	SW-4	10.4 mi	225°	6.5±0.5	Eastmont

TABLE A-9 CONTINUED

Sector	Station No.	Distance	Direction	Gross Reading[a] mR	Location
WSW	W-2	1.3 mi	252°	5.7±0.5	Goldsboro
	W-3a*	4.4 mi	247°	5.0±0.4*	
W	W-1	1.3 mi	263°	7.3±0.9	Goldsboro
	W-3	2.9 mi	270°	6.5±0.5	
	W-4	5.9 mi	272°	7.9±0.6	Lewisberry
	W-5	7.4 mi	262°	5.8±0.5	Lewisberry
WNW	NW-1	2.6 mi	303°	7.2±0.7	Harrisburg-York Airport
	NW-3	7.4 mi	297°	6.2±0.2	New Cumberland
NW	NW-2	5.9 mi	310°	5.3±0.5	Highspire
	NW-4	9.6 mi	306°	4.1±0.2	Harrisburg
	NW-5	13.8 mi	312°	5.3±0.2	Harrisburg
NNW	N-1b*	2.75 mi	346°	4.9±0.4*	
	N-1d*	3.5 mi	333°	5.0±0.3*	

*dosimeters placed at schools 4/5/79-5/3/79

[a]"Gross" no transit dose or background dose corrections made

period March 28th to March 29th, the TLD readings would indicate that the highest dose that could have been received would be between 1.2 - 1.4 rem (Table A-10). This would be approximately a factor of 14 below the 20 rem whole body dose criterion in Section 140.84(a) of 10 CFR Part 140. Calculations (by the Ad Hoc Interagency Dose Assessment Group and confirmed by the Presidential Task Group on Health Physics and Dosimetry) indicated that the combined beta and gamma radiation dose to the skin would be approximately 5 times (range 3-6.5) higher than the whole body dose so the maximum possible skin dose would be around 9 rem. This is a factor of 6.6 times lower than the 60 rem skin dose criterion in 10 CFR Part 140.

All of the previous dose values represent hypothetical "could have been" situations when, in fact, there were no known individuals at these locations throughout the initial period of the accident at Three Mile Island. Estimates of the doses at locations where people actually were are much lower, below 0.1 rem (100 millirem) without residential shielding or occupancy corrections and below 0.07 rem (70 millirem) when allowances for occupancy time and structural shielding are made. A comparison of individual dose estimates made by various groups is presented in Table A-11. Estimates of the collective (population) dose are shown in Table A-12. In both cases, the estimates are close to the estimates derived by the Ad Hoc Interagency Dose Assessment Group.

TABLE A-10 ESTIMATED DOSES THAT COULD HAVE BEEN RECEIVED BY A HYPOTHETICAL INDIVIDUAL LOCATED AT THE LOCATION OF HIGHEST MEASURED DOSE ON SITE (16S1 IN NNW SECTOR) OR ON KOHR ISLAND (16A1)

Conditions of Estimate	TLD Site	12/27/78-3/29/78	8/29/78-3/21/78	3/31/78-4/3/79	4/3/79-4/6/79	4/6/79-4/9/79	4/9/79-4/12/79	4/12/79-4/15/79
		CUMULATIVE DOSE (mR)						
Actual net TLD Dose Readings	16S1	1025	1108	1115	1116	1116	1116	1116
	16A1	902*	947	948	949	950	950	950
Corrected for Energy Dependence of TLD Response	16S1	861	917	921	921	921	921	921
	16A1	758*	788	789	790	790	790	790
Allowance for 99.9 percentile upper bound statistical error and 15% systematic error (no energy correction)	16S1	1292	1392	1399	1400	1400	1400	1400
	16A1	1143*	1186	1188	1189	1189	1189	1189

*Note: A second TLD on Kohr Island read a net dose of 447 mR. The higher value, has been taken.

TABLE A-11 SUMMARY OF ESTIMATED OFFSITE INDIVIDUAL DOSES FROM AIRBORNE NOBLE GASES RELEASED FROM THE THREE MILE ISLAND ACCIDENT

Location	Sector	Distance (miles)	Estimated Dose mR	Period used for Estimate	Correction for Occupancy	Correction for Shielding	Correction for Energy Reponse	Source of Estimate
East Bank	ENE	0.5	83	3/28/79-4/6/79	No	No	No	Ad Hoc Task Group
	ENE	0.5	43	3/28/79-4/15/79	No	No	Yes	Presidential Commission T.G.
	ENE	0.5	43	3/28/79-4/28/79	No	No	No	Pickard, Lowe, and Garrick
	NNE	0.5	76	3/28/79-4/28/79	No	No	No	Pickard, Lowe, and Garrick
	NNE	0.4-1.0	54	3/28/79-4/15/79	No	No	Yes	Presidential Commission T.G.
general			20-70	3/28/79-4/15/79	No	Yes	Yes	Presidential Commission T.G.
	E	0.5	200	3/28/79-4/3/79	No	No	No	DOE contractor personnel***
Hill Island	NNW	1.1	168(low)	3/28/79-3/31/79	No	No	No	Ad Hoc Task Group
	NNW	1.1	256(ave.)	3/28/79-3/31/79	No	No	No	Ad Hoc Task Group
	NNW	1.1	344(high)	3/28/79-3/31/79	No	No	No	Ad Hoc Task Group
	NNW	1.1	37(low)**	3/28/79-3/31/79	Yes	No	No	Ad Hoc Task Group
			93(ave.)	3/28/79-3/31/79	Yes	No	No	Ad Hoc Task Group
			180(high)	3/28/79-3/31/79	Yes	No	No	Ad Hoc Task Group
	NNW	1.1	200±50	3/28/79-4/3/79	No	No	No	DOE contractor personnel***
	NNW	1.1	23	3/28/79-3/29/79	Yes	No	No	Pickard, Lowe, and Garrick
	NNW	1.1	48	3/28/79-3/31/79	Yes	No	Yes	Presidential Commission T.G.
Southeast Bank	SE	0.4-1.0	100-300*	3/28/79-4/15/79	No	No	Yes	Presidential Commission T.G.

*Possible spurious valve as it is based upon extrapolation from a TLD reading 9 miles from site.

**Best estimate - results for low, high med average (ave.) depend upon whether the high TLD reading (902 mR), low TLD reading (447 mR), or average of the two TLD readings (674 mR) are used for the TLD's on Kohr Island (for 9/27/78-3/29/79).

***Results in Appendix A of Ad Hoc Interagency Dose Assessment Group Report (4)

TABLE A-12 SUMMARY OF POPULATION DOSE ESTIMATES FOR THE THREE MILE ISLAND ACCIDENT

Source of Estimate	Method of Assessment	Period	Collective (Population) Dose person-rem		
		Covered by Estimate	Lower bound Estimate	Central Estimate	Upper Bound Estimate
Ad Hoc Interagency Dose Assessment Group	Thermoluminescent dosimeters and extrapolation function	3/28-4/7	1600	3300	5300
Presidential Commission Task Group on Health Physics and Dosimetry	Thermoluminescent dosimeters and extrapolation function	3/28-5/1			
	(no correction for shielding)		1020	2785	6610
	(corrected for shielding)		600	2050	6480
Ad Hoc Interagency Dose Assessment Group	Thermoluminescent dosimeters and meteorological dispersion model	3/28-3/31	-	2600	-
Presidential Commission Task Group on Health Physics and Dosimetry	Estimated Source term and various meteorological dispersion models	3/28-4/7	280	390	970
DOE contractor personnel	Aerial survey data and atmospheric dispersion models	3/28-4/3	1000	2000	2500
Pickard, Lowe, and Garrick, Inc. (consultants to Metropolitan Edison Company)	Thermoluminescent dosimeters, area monitor readings and atmospheric dispersion models	3/28-4/30	2100	3500	6840
NRC staff recalculation of result (a)	Thermoluminescent dosimeters and meteorological dispersion model	3/28-3/31	-	3360	-

B. SURFACE DEPOSITION MEASUREMENTS

1. Description

Radioactive materials released as a result of accidents may deposit on the ground if they are particulates or gases that can be absorbed by soil or vegetation.* These deposited radioactive materials may result in radiation doses to people by several mechanisms:

a. inhalation of deposited material that has become airborne again (resuspended material),

b. ingestions of food products contaminated by direct deposition or through ingestion of contaminated food products (milk, meat) from animals that consumed contaminated forage (direct foliar deposition),

c. ingestion of food products grown on land that was contaminated or food products from animals that grazed on contaminated land (soil-plant transfer),

d. exposure to beta and gamma radiation from radioactive materials deposited on the ground (external irradiation from deposited materials).

*Noble gases, such as xenon or krypton, are not absorbed to an appreciable extent and therefore do not deposit out on the ground. Certain gases, such as radioactive iodine or tritiated water vapor, can be absorbed and result in surface deposition.

One aspect of determining whether a substantial release of radioactive material occurred from a nuclear facility would be to measure radionuclide deposition onto soil or vegetation. These measurements would provide a basis for assessing the possible magnitude of radiation exposures due to the four pathways listed above. These measurements would also provide indication of the possible damages due to land use restrictions or property loss from radioactive contamination.

2. Criteria

Section 140.84 of 10 CFR Part 140 defines surface contamination levels that would be indications of substantial releases of radioactive materials from licensed facilities. These criteria are given separately for offsite property contigious to the site that is owned or leased by the person with whom an indemnity agreement is executed (land adjacent to the site which is owned or leased by the licensee) and for other offsite property as shown in Table B-1. Evidence of a substantial release of radioactive materials would be shown if surface contamination of at least a total of 100 square meters of offsite property occurred in excess of any of the levels shown in Table B-1.

3. Measurements

Measurements of deposited activity were not performed under conditions identical to those specified in 10 CFR Part 140, Section 140.84

Table B-1. Total Surface Contamination Levels
(Maximum levels above background observed or projected, 8 or more hours after initial deposition)

Type of Emitter	Column 1 Offsite property, contigious to site, owned or leased by person with whom an indemnity agreement is executed	Column 2 Other offsite property
Alpha emission from transuranic isotopes	3.5 microcuries per square meter	0.35 microcuries per square meter
Alpha emission from isotopes other than transuranic isotopes	35 microcuries per square meter	3.5 microcuries per square meter
Beta or gamma [e]mission	40 millirads/hour at one centimeter (measured through not more than 7 milligrams per square centimeter of total absorber)	4 millirad/hour at one centimeter (measured through not more than 7 milligrams per square centimeter of total absorber)

until September 14, 1979. Prior to this date, measurements of beta/gamma dose rates were made with survey instruments at approximately "waist-height" rather than 1 centimeter above the ground surface. The instruments generally used also had unshielded ("beta shield" open) window thicknesses of 30 milligrams per square centimeter instead of the 7 milligrams per square centimeter as required by Section 140.84. The use of these survey instrument readings as indications of ground contamination is further complicated by their being influenced by any beta and gamma dose contributions from the radioactive gas plume passing nearby. Because of these complications, the beta/gamma survey readings made during the accident are judged not to be suitable for determining surface contamination levels for the purpose of comparison with the surface contamination criteria in Section 140.84 of 10 CFR Part 140.

a. Thin-Window Survey Measurements

Thin-window beta/gamma readings were made in September 1979 specifically to determine whether there was any long-lived radioactive contamination of land adjacent to the Three Mile Island site. These measurements were made at 12 offsite locations choosen to reflect areas of maximum potential contamination (Figure B-1). Measurements were made one centimeter above the ground surface using an Eberline E120/HP210 probe. This probe has a "window" (absorber thickness) of 2 milligrams per square centimeter, considerably

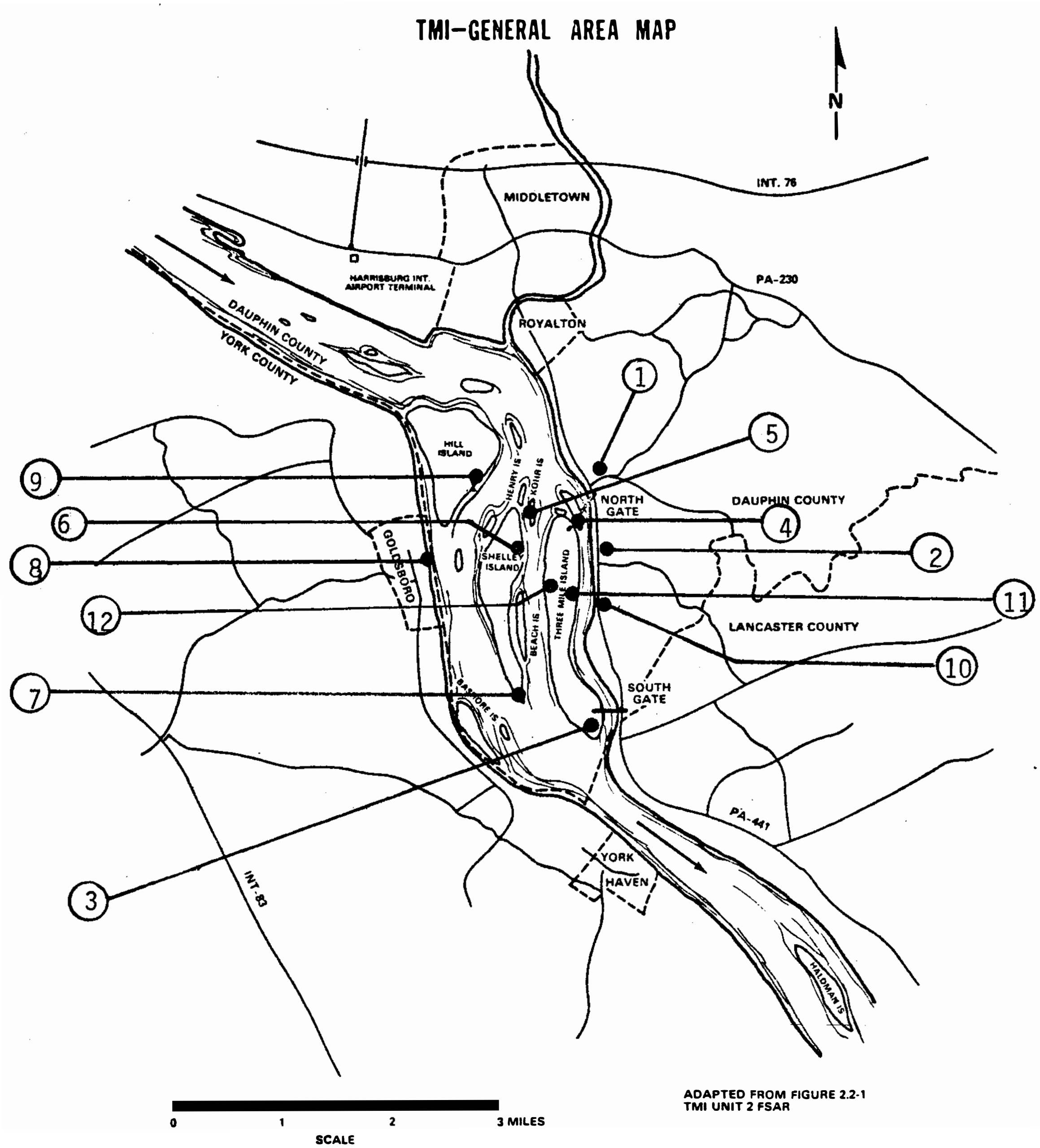

Figure B-1 Location of Special Soil Sampling Sites less than the maximum 7 mg/cm2 thickness specified in section 140.84(b) of 10 CFR Part 140.

Although these measurements were made under conditions consistent with those in section 140.84(b), they were made approximately six months after the principal radionuclide releases from the Three Mile Island accident. Relatively short-lived radionuclides, such as the 8-day radioiodine-131, would have undergone considerable decay in this interval. In order to determine whether there was any significant surface contamination due to short-lived radionuclides, three additional types of measurements were reviewed:

(1) analyses of radioactive materials in soil,
(2) external measurements of surface contamination, and
(3) measurements of radioactive materials deposited onto vegetation.

These measurements were made during and immediately after the period of major releases of radioactive materials from the accident and continued through August 1979. They would provide evidence of surface contamination by short-lived radionuclides as well as more persistent contamination by longer lived radionuclides.

b. Soil Sample Analysis

Direct measurements of soil contamination were made by the NRC Inspection and Enforcement Staff. Soil samples were collected by the NRC staff over areas of approximately 1 square foot, and approximately 1 inch (2.54 cm) in depth. These samples were weighed and then analyzed in the Region I mobile laboratory by gamma spectrometry. A lithium-drifted germanium semi-conductor (Ge(Li)) detector was used for this analysis. A total of 65 samples was taken by NRC in the period from March 29, 1979 to August 14, 1979. Additional soil samples were also collected and analyzed by two contractors to the Metropolitan Edison Company and by the Environmental Protection Agency.

An additional 13 soil samples were collected on September 14, 1979 at the sites of the thin-window beta/gamma measurements. These samples were sent to the Department of Energy Idaho National Engineering Laboratory for gamma spectrometric analyses. These analyses were performed using a lithium-drifted germanium detector and computerized spectrum analysis. Analyses were requested for the following radionuclides: Te-129m, Cs-137, Cs-134, Ru-103, Ru-106, Zr-95, Nb-95, I-131, Sb-124, Sb-125, La-140, Ag-110m, Ce-141, and Ce-144. These radionuclides were identified in a sample of the reactor coolant taken on August 28, 1979 and, therefore, represented the most likely radionuclides to be present. In addition, the samples were analyzed for gross alpha and gross beta activities.

The gamma spectrometric analysis would detect the presence of iodine-131 and cesium-137, which are gamma emitting radionuclides, but would not detect radionuclides emitting only alpha particles or only beta particles. Air sample and air filter analyses reported by the Department of Energy do not indicate the presence of airborne alpha-emitting radionuclides other than naturally occurring radon daughters. The gross alpha analysis results on soil are consistent with the reported levels of naturally occurring thorium or radium daughter radionuclides identified by gamma spectrometry. Beta emitting radioiostopes such as strontium-89 and strontium-90 would be detected by gamma spectrometry (by their bremsstrahlung radiation) only if present in large quantities. For this reason, the samples collected on September 14, 1979 having the highest gross beta readings were analyzed radiochemically for strontium. Low energy beta-emitting radioisotopes (such as tritium or carbon-14) would not be detected by either the radiochemical or gamma spectrometric analyses. However, these two radionuclides would not be detectable by survey instruments with 7 mg/cm^2 windows and therefore would not be included in the 10 CFR Part 140 criteria. The detection sensitivity for the iodine-131 and cesium-137 varied with the sample size but was typically less than 2.69×10^{-3} microcuries per square meter (0.25 nanocuries per square foot).

In order to relate these measurements to the criteria in Section 140.84 of 10 CFR Part 140, it was necessary to calculate the beta and gamma dose rates that would be produced by a unit surface deposition of the radionuclides detected in these samples. These calculations were performed by the staff of the Oak Ridge National Laboratory and are shown in Table B-2. Based upon these calculations, the dose rates for the Section 140.84 measurement conditions that correspond to the minimum detectable concentrations would be:

cesium-137	1.12×10^{-3} mrem/hour
iodine-131 (excluding xenon-131m daughter)	0.95×10^{-3} mrem/hour

These dose rates (approximately 1 microrem per hour) are about one-tenth of the natural background dose rate (0.01 mrem/hour) and would be far more sensitive indicators of surface contamination than would the external beta/gamma dose rate measurements called for in Section 140.84* of 10 CFR Part 140.

c. Other Surface Contamination Measurements

The Environmental Measurements Laboratory (EML) of the Department of Energy made direct measurements of radionuclide deposition using high-pressure ionization chambers (HPIC) and

*Section 140.84 does not specify the medium in which the dose rate criteria apply. For this reason, a tissue dose equivalent (kerma) rate was used in units of millirem/hour rather than millirad/hour.

Table B-2 Radiation Dose (Equivalent) Rate Factors for Deposited Radionuclides

	millirem/year per microcurie/cm^2 [a]			millirem per hour per microcurie per m^2 [b]	Surface deposition (microcuries/m^2) equivalent to 4 millirem per hour[c]
	Photon	Electron	Total		
Strontium-89	3.4×10^{2}	3.7×10^{7}	3.7×10^{7}	0.422	9.47
Strontium-90	-	3.2×10^{7}	3.2×10^{7}	0.365	(10.95)[d]
Yttrium-90	6.6×10^{1}	3.7×10^{7}	3.7×10^{7}	0.422	
Total (^{90}Sr)	6.6×10^{1}	6.9×10^{7}	6.9×10^{7}	0.788	5.08
Iodine-131	1.0×10^{6}	3.0×10^{7}	3.1×10^{7}	0.354	(11.3)[d]
Xenon-131m	2.2×10^{5}	4.0×10^{7}	4.02×10^{7}	0.459	
Total (^{131}I)	1.22×10^{6}	7.0×10^{7}	7.12×10^{7}	0.813	4.92
Cesium-137	-	3.1×10^{7}	3.1×10^{7}	0.354	
Barium-137m	1.6×10^{6}	3.9×10^{6}	5.5×10^{6}	0.063	
Total (^{137}Cs)	1.6×10^{6}	3.49×10^{7}	3.65×10^{7}	0.417	9.60
Cobalt-60	5.78×10^{6}	2.03×10^{7}	2.61×10^{7}	0.298	13.4
Cesium-134	3.97×10^{6}	2.32×10^{7}	2.72×10^{7}	0.310	12.9
Cerium-144	7.55×10^{4}	1.87×10^{7}	1.88×10^{7}	0.214	(18.6)[d]
Pr-144	6.99×10^{4}	3.71×10^{7}	3.72×10^{7}	0.425	
Pr-144m	1.75×10^{5}	-	0.0175×10^{7}	0.002	
Total	3.204×10^{5}	5.58×10^{7}	5.61×10^{7}	0.641	6.24

Footnotes: see next page

Table B-2 Radiation Dose (Equivalent) Rate From Deposited Radionuclides (continued)

Footnotes:

(a) Tissue Kerma in air calculated for an air thickness equivalent to an absorber of 7 milligrams per square centimeter areal density. Calculations performed by D. C. Kocher, Oak Ridge National Laboratories by a modification of the technique described in D. C. Kocher, "Dose-Rate Conversion Factors for External Exposure to Photon and Electron Radiation from Radionuclides Occurring in Routine Releases from Nuclear Fuel Cycle Facilities", Nuclear Regulatory Commission contractor report NUREG/CR-0494, April 1979.

(b) Millirem/year per microcurie/square centimeter divided by 8.76×10^3 hours/year and 10^4 square centimeters per square meter

(c) 4 millirem per hour divided by total (parent plus daughter) millirem per hour per microcurie per square meter

(d) Value for parent radionuclide only

portable gamma spectrometers. These measurements were made during the period from April 2 to April 25, 1979 and the results have been published.*

Measurements of deposition were made in various directions within 10 km (6.2 miles) based upon estimates of possible maximum deposition. Measurement locations were selected to give representative measurements of deposition on relatively large, open, flat areas such as lawns, pastures, and fields.

The high-pressure ionization chambers have walls considerably thicker than the 7 milligrams per square centimeter maximum absorber density required by Section 140.84(b) of 10 CFR Part 140 and therefore are not applicable. With the exception of measurements where there was direct evidence of the presence of the noble gas cloud, these measurements were generally less than typical background dose rates (10 microrads/hour).

d. Vegetation Sampling

Selected vegetation samples were collected and analyzed by the NRC Region I Inspection and Enforcement staff. Approximately 125 samples of grass and other vegetation (excluding food crops which were separately categorized) were collected and analyzed

*K. Miller, C. Gogolak, M. Boyle, and J. Gubin, "Radiation Measurements Following the Three Mile Island Reactor Accident", Environmental Measurements Laboratory report EML-357, May 1979.

by gamma spectrometry. Samples generally consisted of the vegetation over 1 square meter of area. Typical minimum detectable activities for these samples were 0.10 nanocuries per square meter (0.0001 microcuries per square meter) for iodine-131 and cesium-137. Vegetation samples were also collected and analyzed by Metropolitan Edison contractors.

The vegetation sample results cannot be used directly to estimate total deposition as they do not include any material that might have deposited directly onto soil. Approximate values for the fraction of material retained on the vegetation of 0.25 and 0.1 were used* to provide estimates of possible total deposition.

4. Results

a. Soil Contamination Measurements

All measurements taken on September 14, 1979 with a thin-window detector (2 mg/cm2) were within background levels (20 counts per minute).

*This fraction ranges between 0.006 and 0.85. (See H. T. Peterson, Jr. and J. M. Smith, "Guides for Predicting Thyroid Dose from Environmental Measurements Following Radioiodine Releases", Chapter 23 in Environmental Surveillance in the Vicinity of Nuclear Facilities (W. C. Reinig, ed.) C. C. Thomas (1970).

b. Soil Sample Analysis

Seven of the 65 soil samples taken before September 1, 1979, had measurable levels of cesium-137. With the exceptions of naturally occurring potassium-40 and daughters of radium and thorium, other gamma-emitting radionuclides were detected in only two samples. These samples were from an onsite area where low-level contaminated material had been temporarily stored. One of these samples showed measurable levels of cesium-134 and cobalt-60 in addition to cesium-137. The other sample had measurable levels of iodine-131, but the other radionuclides were below detectable limits. The results of the positive analyses are shown in Table B-3 together with the estimated dose rates.

The results of the additional soil samples collected on September 14, 1979, are shown in Table B-4. Although there are indications of possible traces of several radionuclides, the only measurable radionuclides (in addition to naturally occurring radionuclides that would be expected to be present) were cesium-137 and cerium-144. Cesium-137 was present in most samples but measurable levels of cerium-144 were detected only at two locations. The estimated dose rates from the measurable activities are shown in Table B-5.

The reported results of other organizations that performed analyses on soil are shown in Table B-6. These results cannot

Table B-3. NRC Soil Samples Showing Radionuclide Concentrations Above Minimum Detectable Levels and Relationship to 10 CFR Part 140 Criteria

Date of Collection	Location (Sample #)	Distance Miles	Direction °(N=0°)	Radionuclide Detected (a)	Measured Activity pCi/g Soil	Measured Activity nCi/ft^2 (b)	Measured Activity $\mu Ci/m^2$ (c)	Estimated Dose Rate (millirem/hour) (d)	Fraction of Part 140 Criterion (=4 millirem/hour)
4/20/79	E-10 (862)	0.85	127	Cs-137	0.46 ± 0.09	0.14 ± 0.03	$1.50(\pm0.32)x10^{-3}$	$6.3(\pm1.35)x10-4$	$1.57(\pm0.34)x10-4$
5/16/79	TMI Landfill* (1480)	0.65	170	Cs-137	10.4 ± 0.2	6.45 ± 0.14	$6.94(\pm0.15)x10^{-2}$	$2.90(\pm0.06)x10^{-2}$	$7.25(\pm0.16)x10^{-3}$*
				Cs-134	5.99 ± 0.18	3.73 ± 0.11	$4.01(\pm0.12x10^{-2}$	$1.24(\pm0.04)x10^{-2}$	$3.1(\pm0.01)x10^{-3}$*
				Co-60	0.97 ± 0.10	0.60 ± 0.06	$6.46(\pm0.64)x10^{-3}$	$1.92(\pm0.19)x10^{-3}$	$4.8(\pm0.05)x10^{-4}$*
5/16/79	TMI Landfill* (1481)	0.65	170	I-131	0.90 ± 0.05	0.59 ± 0.04	$6.35(\pm0.43)x10^{-3}$	$1.79(\pm0.18)x10^{-2}$	$4.48(\pm0.04)x10^{-3}$*
							Total	$6.12(\pm0.19)x10^{-2}$	$1.53(\pm0.05)x10^{-2}$*
5/20/79	Farm Pasture (1581)	-	-	Cs-137	0.88 ± 0.07	0.48 ± 0.04	$5.17(\pm0.43)x10^{-3}$	$2.15(\pm0.18)x10^{-3}$	$5.39(\pm0.04)x10^{-4}$
5/20/79	E-14 (1882)	2.5	160	Cs-137	0.73 ± 0.07	0.47 ± 0.05	$5.06(\pm0.54)x10^{-3}$	$2.11(\pm0.22)x10^{-3}$	$5.27(\pm0.56)x10^{-4}$
5/22/79	E-2 (1798)	2.35	354	Cs-137	0.48 ± 0.06	0.32 ± 0.04	$3.44(\pm0.43)x10^{-3}$	$1.44(\pm0.18)x10^{-3}$	$3.59(\pm0.45)x10^{-4}$
5/22/79	E-11 (1732)	1.15	153	Cs-137	0.16 ± 0.05	0.09 ± 0.03	$9.69(\pm3.23)x10^{-4}$	$4.04(\pm1.35)x10^{-4}$	$1.01(\pm0.34)x10^{-4}$
6/5/79	Boat Club (1859)	-	-	Cs-137	0.51 ± 0.09	0.35 ± 0.06	$3.77(\pm0.64)x10^{-3}$	$1.57(\pm0.27)x10^{-3}$	$3.93(\pm0.67)x10^{-4}$

*This sample is from an area that had been used to bury low-level waste. This was not permitted under the license conditions and this waste was retrieved and shipped to an authorized burial ground and the area was decontaminated. The applicable criterion would be 40 millirad/hour.

(a) Fission or activation product activity. This excludes the naturally occurring potassium-40 (which was measured in all samples) and radium and thorium daughter products. Neither of these other types of radionuclides would be present in the reactor in appreciable quantities.

(b) The error term represents one standard deviation based upon counting statistics.

(c) Results reported as nanocuries per square foot times 10^{-3} microcuries per nanocurie and divided by 0.0929 square meters per square foot.

(d) Deposited activity (in $\mu Ci/m^2$) times the dose factor given in Table B-2.

Table B-4. Results of Special Soil Analyses for Long-lived Gamma-emitting Radionuclides

Sample #	Distance (Miles)	Direction (0°=N)	Location	Fission and Activation Product Radionuclides[a]: Possible traces indicated[b] Nuclide	pCi/g ± 1.S.D.	Measurable Levels[c] Nuclide	pCi/g ± 1.S.D.	Level for[d] Acceptance
1	1.2	64°	Sunset Park	Sb-124	0.0798 ± 0.036			0.119
2a	0.5	95°	Observation Center	Cs-137	0.155 ± 0.023	Cs-137	0.155 ± 0.023	0.076
2b	0.5	95°	Observation Center	Cs-137	0.195 ± 0.04	Cs-137	0.195 ± 0.04	0.132
3	1.7	145°	South end TMI	Cs-137	0.468 ± 0.031	Cs-137	0.468 ± 0.031	0.102
				La-140	0.055 ± 0.017			0.056
4	0.4	81°	Sandy Beach Island	Cs-137	0.124 ± 0.032	Cs-137	0.124 ± 0.032	0.105
				Ru-103	0.031 ± 0.017			0.056
				Ce-141	0.06 ± 0.03			0.099
5	0.4	79°	Kohr Island	Cs-134	0.018 ± 0.0079			0.026
				Cs-137	0.178 ± 0.022	Cs-137	0.178 ± 0.022	0.072
				Sb-125	0.084 ± 0.04			0.132
				Ce-144	0.14 ± 0.054			0.178
6	0.4	270°	Shelley Island N.	Cs-137	0.285 ± 0.026	Cs-137	0.285 ± 0.026	0.086
				Te-129m	2.89 ± 1.6			5.27
				Ce-144	0.119 ± 0.056			0.184
7	1.4	215°	Shelley Island S.	Cs-137	0.366 ± 0.034	Cs-137	0.366 ± 0.034	0.112
				Zr-95	0.05 ± 0.028			0.090
				La-140	0.045 ± 0.026			0.086
				Ce-144	0.24 ± 0.069	Ce-144	0.24 ± 0.069	0.227
				Co-60	0.033 ± 0.019			0.063
8	1.4	270°	Goldsboro	Cs-137	0.668 ± 0.035	Cs-137	0.668 ± 0.035	0.115
				Ru-106	0.59 ± 0.19			0.626
				La-140	0.065 ± 0.033			0.110
9	1.1	298°	Hill Island	La-140	0.045 ± 0.014			0.046

Table B-4. Results of Special Soil Analyses for Long-lived Gamma-emitting Radionuclides (Continued)

Sample #	Distance (Miles)	Direction (0°=N)	Location	Fission and Activation Product Radionuclides[a]: Possible traces indicated[b] Nuclide	pCi/g ± 1.S.D.	Measurable Levels[c] Nuclide	pCi/g ± 1.S.D.	Level for[d] Acceptance
10	0.5	167°	Riverbank East of TMI	Cs-134	0.023 ± 0.010			0.033
				Cs-137	0.741 ± 0.043	Cs-137	0.741 ± 0.043	0.145
				Zr-95	0.053 ± 0.022			0.074
				La-140	0.42 ± 0.018			0.061
11	0.4	180°	Middle of TMI	Cs-137	0.315 ± 0.028	Cs-137	0.315 ± 0.028	0.095
				Sb-125	0.132 ± 0.057			0.193
				Ru-106	0.464 ± 0.19			0.642
				Ce-144	0.893 ± 0.14	Ce-144	0.893 ± 0.14	0.513
12	0.2	264°	West Part of TMI	Cs-137	0.308 ± 0.026	Cs-137	0.308 ± 0.026	0.095
				Ce-144	0.21 ± 0.097			0.355

Footnotes

(a) In addition to these radionuclides, the following radionuclides of natural origin were detected in these samples: potassium-40, lead-214, bismuth-214, and occassionally protocatinium-234m daughters of radium; lead-212, bismuth-212, thallium-208, and actinium-228 daughters of thorium-232; and cosmic-ray produced beryllium - 7 (in 5 samples).

(b) A radionuclide is considered to be absent if the reported result is negative, or if the result of subtracting 1.6475 times the standard deviation s from the reported result is zero or negative ($0 \geq x - 1.6475s$). (Note: the analytical laboratory that performed these analyses reports results as "not detected" when 2 standard deviations from the reported result would include zero ($x - 2s \leq 0$).) A radionuclide is considered to be possibly present in trace quantities but at levels too low to permit accurate quantification when $x - 2(1.6475)s < 0 < x - 1.6475s$.

(c) A radionuclide is considered to be present in measurable quantities when $0 \leq x - 2(1.6475)s$.

(d) This is $2(1.6475)s = 3.295$ x the standard deviation reported and represents the value which would have to be exceeded in order to consider the levels to be measurable.

Table B-5. Estimated Beta/Gamma Dose Rates from Measured Levels of Radioactive Materials in Soil

Sample #	Location	Sample Weight(g)	Area(m^2)[a]	Nuclide	Total Activity(pCi) (b)	Deposition[c] ($\mu Ci/m^2$)	Dose rate[d] (mrem/hr)	Fraction of 10 CFR Part 140 4 millirem/hour criterion [e]
1	Sunset Park	105	0.0929	No Measurable activity				
2a	Observation Center	108	0.0929	Cs-137	16.7 ± 2.4	1.8 (± 0.26) 10^{-4}	7.5(± 1.1) x 10^{-5}	1.87(± 0.27) x 10^{-5}
2b	Observation Center	110	1	Cs-137	21.4 ± 4.4	2.14(± 0.44) x 10^{-5}	8.92(± 1.83) x 10^{-6}	2.23(± 0.46) x 10^{-6}
3	South end TMI	94.4	0.0929	Cs-137	44.2 ± 2.9	4.75(± 0.31) x 10^{-4}	1.98(± 0.13) x 10^{-4}	4.95(± 0.32) x 10^{-5}(f)
4	Sandy Beach Island	105	0.0929	Cs-137	13.0 ± 3.4	1.40(± 0.36) x 10^{-4}	5.83(± 1.5) x 10^{-5}	1.46(± 0.38) x 10^{-5}(f)
5	Kohr Island	121	0.0929	Cs-137	21.5 ± 2.7	2.30(± 0.29) x 10^{-4}	9.64(± 1.2) x 10^{-5}	2.41(± 0.30) x 10^{-5}
6	Shelley Island N.	105	0.0929	Cs-137	29.9 ± 2.7	3.22(± 0.29) x 10^{-4}	1.34(± 0.12) x 10^{-4}	3.35(± 0.31) x 10^{-5}(f)
7	Shelley Island S.	112	0.0929	Cs-137 Ce-144 Total	41.0 ± 2.9 26.9 ± 7.7 -	4.41(± 0.31) x 10^{-4} 2.89(± 0.83) x 10^{-4} -	1.84(± 0.13) x 10^{-4} 1.85(± 0.53) x 10^{-4} 3.7 (± 0.55) x 10^{-4}	- - 9.24(± 1.4) x 10^{-5}
8	Goldsboro	83.0	0.0929	Cs-137	55.4 ± 2.9	5.97(± 0.31) x 10^{-4}	2.49(± 0.13) x 10^{-4}	6.22(± 0.33) x 10^{-5}
9	Hill Island	116	0.0929	No Measurable Activity				
10	Riverbank East of TMI	95.0	0.0929	Cs-137	70.4 ± 4.1	7.58(± 0.44) x 10^{-4}	3.16(± 0.18) x 10^{-4}	7.9(± 0.46) x 10^{-5}
11	Middle of TMI	81.0	0.0929	Cs-137 Ce-144 Total	25.5 ± 2.3 72.3 ±11.3	2.75(± 0.24) x 10^{-4} 7.79(± 1.2) x 10^{-4}	1.14(± 0.10) x 10^{-4} 4.99(± 0.78) x 10^{-4} 6.13(± 0.79) x 10^{-4}	1.53(±0.20) x 10^{-4}(f)
12	West Part of TMI	104	0.0929	Cs-137	32.0 ± 2.7	3.45(± 0.29)x 10^{-4}	1.44(± 0.12) x 10^{-4}	3.60(±0.30) x 10^{-5}(f)

Footnotes

(a) Area of sample. All samples were taken over 1 square foot (0.0929 m^2) to a depth of 1 inch except sample #2b which was taken over an area of 1 square meter with a standard coring tool.

(b) Activity in pCi/gram (from Table B-4) times the sample weight in grams.

(c) Total activity in pCi x 10^{-6} μCi/pCi and divided by sample area in m^2.

(d) Deposition ($\mu Ci/m^2$) times the appropriate dose factor from Table B-2 in mrem/hr per $\mu Ci/m^2$.

(e) Predicted dose rate divided by 4 millirem per hour.

(f) These are on-site samples for which the 40 millirad per hour criterion would be applicable. The values presented are compared to the 4 millirad per hour off-site criterion.

Table B-6. Other Soil Analytical Results (from Attachment 2, p. 193 of the draft Report of the Task Group on Health Physics and Dosimetry of the President's Commission on the Accident at Three Mile Island

Radionuclide	Organization	Sampling Dates	Number of Samples Analyzed	Positive Results (pCi/g dry)				MDL* (pCi/g dry)
				Number	Mean	Minimum	Maximum	
Iodine-131	RMC	4/5	3	0	-	-	-	0.07
	Teledyne	4/5	3	0	-	-	-	0.27
	EPA	4/2-4/13	53	0	-	-	-	N.A.**
Cesium-137	RMC	4/2	3	3	0.8±0.2	0.58	1.0	N.A.**
	Teledyne	4/5	3	3	0.4±0.3	0.46	1.38	N.A.**
	EPA	4/2-4/13	53	11	0.6±0.3	0.22	1.1	N.A.**

RMC - Radiation Management Corporation (for the Metropolitan Edison Company)

Teledyne - Teledyne - Isotopes, Inc. (for the Metropolitan Edison Company)

EPA- -Environmental Protection Agency

*MDL - Minimum Detectable Level

**N.A. - Not available

be compared to the Section 140-84(b) criteria because the area sampled is not given. However, only cesium-137 was detected, at levels that are generally consistent with the offsite NRC results (in pCi/g) shown in Table B-3.

Pre-accident cesium-137 levels in soil, measured by the licensee's environmental surveillance program in 1977 in the vicinity of the Three Mile Island site average 0.6 ± 0.8 picocuries per gram* (pCi/g), ranging between 0.17 and 1.5 pCi/g (Table B-7).* With the exception of the one sample on Three Mile Island, the measured cesium-137 concentrations in soil are within this range of pre-accident cesium-137 levels.

Estimated offsite dose rates are generally less than 0.1% of the 10 CFR Part 140 criteria for surface contamination. The one location on Three Mile Island where levels of radioactivity greater than expected from pre-existing fallout were found would also be only a small fraction (1.5%) of the Part 140 dose rate criterion of 4 millirad per hour. However, the 40 millirad per hour criterion would be applicable to this location as it is on licensee-controlled land adjacent to the site. This sample would therefore be less than 0.2% of the applicable criterion.

*Radiological Environmental Monitoring Report - Three Mile Island Nuclear Station - 1977 Annual Report. Prepared for the Metropolitan Edison Company by Teledyne Isotypes, Westwood, New Jersey. (This report is for Three Mile Island Unit No. 1, Docket No. 50-289.) Table B-18 p. 58. Soil analyses were not reported in the 1978 Annual Report.

Table B-7 Average Radionuclide Levels in Soil Samples Collected in the Vicinity of Three Mile Island in 1977.

Radionuclide	Average level pCi/g ± 1.S.D.	Range (pCi/g)
Sr-90	0.17 ± 0.05	<0.05 - 0.22
K-40*	10 ± 3	4.1 - 16
Zr-95	0.08 ± 0.05	<MDL - 0.09
Nb-95	0.07 ± 0.02	<MDL - 0.11
Sb-125	0.2 ± 0.4	<MDL - 0.6
Cs-137	0.6 ± 0.4	0.2 - 1.5
Ce-141	0.05	<MDL - 0.05
Ce-144	0.3	<MDL - 0.3
Ra-226*	0.9 ± 0.35	0.3 - 1.2
Th-228*	0.7 ± 0.15	0.3 - 1.0

Table B-18 p 58 of the Metropolitan Edison Company Radiological Environmental Monitoring Report for the Three Mile Island Nuclear Station, 1977 Annual Report Prepared by Teledyne Isotopes, Westwood, N.J.

*Naturally occurring radionuclides.

Table B-8. Gross Alpha, Gross Beta, and Strontium Results for Special Soil Samples

Sample #	Gross Alpha pCi/g ±1 S.D.	Gross Beta pCi/g ±1. S.D.	Radiochemical Isotopic Analysis	Gross Count (20 min)	Background Count (20 min)	Net Count (20 min) ±1. S.D.	Result pCi/g ±1 S.D.
1.	11.3±0.7	41.±7.	Total Strontium	83	78	5.±13	--
			Strontium-90	91	81	10.±13	0.1±0.1
			Strontium-89		by difference		0.0±0.1
2.	9.2±0.6	32.±8.	Total Strontium	77	78	-1±13	--
			Strontium-90	74	81	-7±13	-0.1±0.2
			Strontium-89		by difference		0.0±0.1
2B.	8.4±0.5	20.±5.	NA	--	--	--	--
3.	11.7±0.7	9.±4.	NA	--	--	--	--
4.	5.8±0.5	9.±5.	NA	--	--	--	--
5.	7.6±0.5	6.±4.	NA	--	--	--	--
6.	8.9±0.6	25.±6.	NA	--	--	--	--
7.	9.5±0.6	23.±6.	NA	--	--	--	--
8.	10.0±0.6	27.±6.	NA	--	--	--	--
9.	8.5±0.5	17.±6.	NA	--	--	--	--
10.	8.3±0.5	22.±6.	NA	--	--	--	--
11.	8.9±0.6	23.±5.	NA	--	--	--	--
12.	9.2±0.6	32.±8.	NA	--	--	--	--

NA - No analysis made

The results of radiochemical analyses for strontium-89 and strontium-90 are shown in Table B-8. These results indicate that these radionuclides, if present, are less than the limits of detection. The reported levels of 0.1 ± 0.1 pCi/g are consistent with pre-accident strontium-90 levels reported by the licensee in 1977 of 0.17 ± 0.05 (Table B-7).

<u>Conclusion</u>: Measured soil activities are generally below the criteria for significant offsite contamination by at least a factor of 200. The principal fission-product radionuclides detected in soil offsite were cesium-137 and cerium-144. These levels may be due to residual fallout from past nuclear testing rather than a result of the accident.

c. <u>Field Gamma Spectrometry</u>

The DOE Environmental Measurements Laboratory made measurements of deposition at 37 locations ranging between 0.6 km (0.4 mi) and 24.9 km (15.5 mi) from the Three Mile Island site. Cesium-137 was detected at levels up to 100 nCi/m^2 (0.1 microcuries/m^2) and was attributed to be from worldwide residual fallout from atmospheric nuclear tests. Iodine-131 was detected at 7 sites as shown in Table B-9. All measurements indicate that radioiodine deposition was less than 2 nCi/m^2 (0.002 microcuries/m^2). Using the factor given in Table B-2

Table B-9 Radioiodine Deposition Measurements above Detectable Limits Reported by the Department of Energy Environmental Measurements Laboratory*

Location #	Distance (miles)	Direction (degrees)	sector	Date	Radioiodine Deposition nCi/m^2	$\mu Ci/m^2$	Estimated Beta/Gamma Dose Rate (mrem/hr)[(a)]	Fraction of 140.84 4 mrem/hr criterion
EML 8	1.2	5	N	4/3/79	0.4 ± 0.3	$4(\pm 3)\times 10^{-4}$	$1.4(\pm 1.1)\times 10^{-4}$	3.5(±2.8)x10-5
12	1.8	162	SSE	4/4/79	0.6 ± 0.3	$6(\pm 3)\times 10^{-4}$	$2.1(\pm 1.1)\times 10^{-4}$	$5.2(\pm 2.8)\times 10^{-5}$
13	1.9	309	NW	4/5/79	0.2 ± 0.2	$2(\pm 2)\times 10^{-4}$	$7.1(\pm 7.1)\times 10^{-5}$	$1.8(\pm 1.8)\times 10^{-5}$
18	6.3	323	NW	4/7/79	0.4 ± 0.4	$4(\pm 4)\times 10^{-4}$	$1.4(\pm 1.4)\times 10^{-4}$	$3.5(\pm 3.5)\times 10^{-5}$
25	0.5	109	ESE	4/9/79	1.9 ± 0.2	$1.9(\pm 0.2)\times 10^{-3}$	$6.7(\pm 0.71)\times 10^{-4}$	$17(\pm 1.8)\times 10^{-5}$
29	1.9	139	SE	4/10/79	0.4 ± 0.3	$4(\pm 3)\times 10^{-4}$	$1.4(\pm 1.1)\times 10^{-4}$	$3.5(\pm 2.8)\times 10^{-5}$
34	2.5	186	S	4/11/79	0.3 ± 0.3	$3(\pm 3)\times 10^{-4}$	$1.1(\pm 1.1)\times 10^{-4}$	$2.8(\pm 2.8)\times 10^{-5}$

(a) Using the factors from Table B-2

*K. Miller, C. Gogolak, M. Boyle, and J. Gubin, "Radiation Measurements Following the Three Mile Island Reactor Accident," DOE Environmental Measurements Laboratory Report EML-357, May 1979.

for calculating dose rate from radioiodine deposition, the equivalent maximum dose rate would be approximately 0.7 microrem per hour (0.7×10^{-3} mrem/hr) or less than 0.02% of the 10 CFR Part 140 criterion of 4 mrad/hour.

<u>Conclusion</u>: Field gamma spectrometry data shows that small quantities of radioiodine were deposited at several locations, but at levels equivalent to less than 0.02% of the surface contamination criterion given in 10 CFR Part 140.

d. <u>Vegetation Analysis</u>

Detectable levels of iodine-131 were found by NRC on ten samples during the period from mid to late April 1979. This period corresponds to the time that the iodine filter assemblies were being replaced. Nine of the ten samples with detectable activity were within 0.5 to 1.0 miles of the Three Mile Island site*. The results of the samples with detectable activity and estimated dose rates for assumed plant/total retention factors of 0.25 and 0.10 are shown in Table B-10. The maximum total dose rate due to iodine-131 for any sample is 0.0028 millirem/hour using the lower retention factor (0.10). This is less than 0.1 per cent (0.07%) of the 10 CFR Part 140 criterion of 4 millirem per hour.

*The location of the tenth sample is not known.

Table B-10. NRC Vegetation Samples Having Detectable Levels of Radioactive Materials

Date	Location (sample #)	Distance (miles)	Direction °(0°=N)	Radionuclide	Measured Activity (0.001 μCi/m²)	Estimated Dose Rate (mrem/hour)[a] Vegetation/ Total=0.25	Vegetation/ Total=0.25
4/16/79	E-9 (#670)	0.45	130	I-131	0.55±0.03[b]	$7.84(\pm 0.21)\times 10^{-4}$	$1.96(\pm 0.05)\times 10^{-3}$
4/16/79	E-9 (#673)	0.45	130	I-131	0.79±0.04	$1.12(\pm 0.06)\times 10^{-3}$	$2.80(\pm 0.14)\times 10^{-3}$
4/16/79	E-9 (#674)	0.45	130	I-131	0.60±0.04	$8.50(\pm 0.57)\times 10^{-4}$	$2.12(\pm 0.14)\times 10^{-3}$
4/17/79	E-9 (#675)	0.45	130	I-131	0.54±0.04	$7.65(\pm 0.57)\times 10^{-4}$	$1.91(\pm 0.14)\times 10^{-3}$
4/18/79	E-60 (#709)	0.8	175	I-131	0.69±0.05	$9.77(\pm 0.71)\times 10^{-4}$	$2.44(\pm 0.18)\times 10^{-3}$
4/17/79	not given (#804)	-	-	I-131	0.57±0.05	$8.07(\pm 0.71)\times 10^{-4}$	$2.02(\pm 0.18)\times 10^{-3}$
4/20/79	E-10 (#822)	0.85	127	I-131	0.398±0.06	$5.64(\pm 0.08)\times 10^{-4}$	$1.40(\pm 0.21)\times 10^{-3}$
4/29/79	E-9 (#1096)	0.45	130	I-131	0.220±0.029	$3.12(\pm 0.41)\times 10^{-4}$	$7.79(\pm 1.03)\times 10^{-4}$
4/29/79	E-9 (#1098)	0.45	130	I-131	0.305±0.032	$4.32(\pm 0.45)\times 10^{-4}$	$1.08(\pm 0.11)\times 10^{-3}$
4/30/79	E-9 (#1120)	0.45	130	I-131	0.040±0.012	$5.66(\pm 1.70)\times 10^{-5}$	$1.42(\pm 0.42)\times 10^{-4}$

(a) Using the dose factors for iodine-131 from Table B-2 and the vegetation to total deposition factors shown. If the xenon-131m daughter of iodine is included these values would be a factor of 2.3 higher.

(b) In nanocuries/m². This value is 0.55×10^{-3} microcuries/m².

Table B-11. Other Vegetation (Grass) Measurement Results (from Attachment 1, p. 191 of the draft Report of the Task Group and Health Physics and Dosimetry of the President's Commission on the Accident at Three Mile Island)

Radionuclide	Organization	Sampling Dates	Number of Samples Analyzed	Positive Results (pCi/g dry) Number	Mean	Minimum	Maximum	MDL pCi/g
Iodine-131	RMC	4/5	3	0	-	-	-	0.15
	Teledyne	4/5	3	2	0.05±0.02	0.033	0.063	0.01
Cesium-137	RMC	4/5	2	2	0.25±0.1	0.18	0.32	N.A.

MDL - Minimum detectable activity

RMC - Radiation Management Corporation (for the Metropolitan Edison Company)

Teledyne - Teledyne - Isotopes, Inc. (for the Metropolitan Edison Company)

The results would be increased by a factor of 2.3 (0.813/0.354) if 100% retention of the xenon-131m gaseous daughter of iodine-131 were assumed and would be less than 0.2 percent of the 4 millirad per hour criterion.

Conclusion: Estimated beta/gamma dose rates derived from vegetation analyses over a factor of 600 lower than the 10 CFR Part 140 criteria for offsite contamination, assuming that the measured vegetation levels are only one-tenth of the total deposition and including the dose contribution from the xenon-131m daughter of iodine-131.

5. Conclusions

Measurements of potential surface deposition of radioactive materials were made at numerous locations around the Three Mile Island site using a variety of techniques. Beta/gamma survey measurements using a thin window detector (2 mg/cm2) were made at 13 sites on and surrounding Three Mile Island. These measurements were consistent with background radiation levels. Analysis of these soil samples by gamma spectrometry and radiochemical analysis indicated the presence of cesium-137, cerium-144, and strontium-90 but at levels consistent with pre-accident fallout levels.

These special soil measurements would have revealed any long-lived gamma-emitting radionuclides, but, because they were taken six months after the accident, they would not have revealed the presence of short-lived radionuclides. For this reason, soil analyses, vegetation analyses, and ground deposition measurements that were made during the period of major radionuclide releases were also examined. These measurements were made using techniques that were more sensitive than the beta/gamma surveys specified in 10 CFR Part 140 and would have detected any short-lived gamma emitting radionuclides. These analyses showed the presence of cesium-137 and iodine-131 in offsite samples. The cesium-137 levels within the range of pre-accident levels and are attributable to residual contamination from atmospheric nuclear testing. Because of its short half-life (8 days), the radioiodine-131 levels cannot be attributed to pre-existing fallout and can be ascribed to iodine-131 released from the accident. The levels of radioiodine deposition were less than 0.3 per cent of the 10 CFR Part 140 4 millirad per hour surface contamination criterion.

One soil sample collected on Three Mile Island indicated cesium-137 present at levels above typical levels attributable to atmospheric fallout from nuclear testing. This sample also had positive levels of cesium-134 and cobalt-60. This sample was collected from a site that was known to have been used to store low-level contaminated materials. The trace levels of radioactive materials most likely represent residual contamination from the low-level radioactive waste* rather than from radioactive materials arising from the

*These wastes had been removed, packaged and shipped to an authorized burial site prior to the accident.

accident on March 28, 1979. The estimated total beta/gamma dose rate from the cesium-137, cesium-134, cobalt-60, and radioiodine-131 (found in an adjacent sample) would be approximately 1.5% of the 4 millirad per hour criterion. However, the 40 millirad per hour criterion could be applicable to this location as it is on licensee-owned land contiguous to the Three Mile Island site. The estimated dose rate is approximately 0.15% of the 40 millirad per hour criterion.

All measurements indicate that surface contamination levels are factors of 600 to 10,000 times lower than the surface contamination levels that would be required to produce beta/gamma dose rates of the levels specified in section 140.84 of 10 CFR Part 140. These very sensitive measurements do not support a finding that "substantial offsite dose levels" resulted or that "substantial quantities of radioactive materials" were released during the accident as defined by the criteria in the NRC regulations.

ANALYSIS OF THE GEOGRAPHIC COVERAGE PROVIDED BY THE THERMOLUMINESCENT DOSIMETERS

A. Analysis of Wind Direction and Persistence

The adequacy of the geographical coverage provided by the thermoluminescent dosimeters (TLD's) that were in place throughout the initial period (first week) of the accident is an important factor in assessing the dosimetry. The possibility that significant releases of radioactive materials occurred at a time when the wind direction was toward an area where no TLD's were located was evaluated by comparing the TLD locations to the hourly wind direction data from onsite meteorological instrumentation. These instruments are located on a 150-foot tower located at the north end of Three Mile Island. A description of the meteorological instrumentation and the hourly records of wind speed, direction, and atmospheric stability are given in Appendix A - Three Mile Island Meteorological Program and Summary of Post Accident Data to the report prepared by Pickard, Lowe, and Garrick, Inc., consultants to the Metropolitan Edison Co.*

The data for the hourly wind direction taken from the records provided in this report are summarized in Table 1. This table shows the direction

*Pickard, Lowe, and Garrick, Inc., "Assessment of Offsite Radiation Doses from the Three Mile Island Unit 2 Accident," Document TDR-TMI-116, Revision 0, July 31, 1979.

Table 1.

HOURLY WIND DIRECTION FOR THE INITIAL ACCIDENT PERIOD

FIRST WEEK

HOURLY WIND DIRECTION

(direction wind blows from - direction recorded on meteorological instruments).

Hour	March 28	March 29	March 30	March 31	April 1	April 2	April 3
0100	-	S	NE	SSW	SSW	ESE	N
0200	-	SE	NNW	WSW	ESE	ESE	NNW
0300	-	SE	NW	WSW	NE	SE	N
0400	N	ESE	NNE	SW	WNW	ESE	NW
0500	NE	ESE	E	SW	NNW	ESE	NW
0600	E	ESE	SW	SSW	N	ESE	N
0700	E	E	SSW	SW	SW	ESE	NNW
0800	ENE	E	N	WSW	W	E	SE
0900	SSE	ESE	NNW	SW	NW	ESE	NW
1000	WSW	NE	WNW	SW	NE	ESE	NW
1100	W	N	E	SW	N	ESE	NNW
1200	S	SSE	SW	SW	NNW	ESE	NW
1300	S	SSE	SE	WSW	NNW	ESE	NW
1400	SSW	S	SSW	WSW	NNW	SE	N
1500	SSW	NNW	ESE	SSW	NNW	ESE	WNW
1600	SSW	ENE	E	NW	NNW	E	SSE
1700	SSW	NNE	SE	NW	ENE	ESE	NW
1800	SSE	NNE	ESE	W	NE	ENE	NNW
1900	SSE	N	SE	WSW	E	ENE	N
2000	SSE	NNW	SSE	SSW	NE	N	NNW
2100	SSE	NNW	SE	SW	ESE	N	NNW
2200	SSE	N	SE	SW	SE	NNE	NNE
2300	SSE	E	SE	SSW	SE	ENE	NE
2400	SSE	S	SSW	NW	ESE	N	N

that the wind blows from which is the direction indicated on the meteorological records. Thus a Southwest wind blows from the Southwest, towards the Northeast. In order to compare the wind direction and the TLD locations, it is necessary to determine the sector that the wind blows into, i.e., where the wind is going rather than where it is from. The direction that the wind blows toward is the opposite direction from where the wind originates. Thus a Southwestern (SW) wind blows toward the Northeast (NE), a Southern (S) wind blows toward the North (N), etc. The direction the wind blows towards is called the inverted wind direction. Table 2 shows the inverted wind direction for the first week of the accident.

Tables 1 and 2 are based upon hourly meteorological data. These data are based on readings taken every 10 seconds and averaged over a fifteen minute period. The hourly data represents the period from 7½ minutes before the hour to 7½ minutes after the hour. The hourly data therefore represents only 15 minutes out of each hour. In order to determine whether summaries of wind direction based upon hourly readings were representative of the total hour time period, these values were compared with data summarized in the Pickard, Lowe, and Garrick, Inc., report for a four quarter hour periods.* Table 3 shows that the hourly wind direction persistence values are generally consistent with the quarter-hour totals, although there are some minor differences due to wind shifts between the hourly readings.

*Table 4-3. Note that the column heading "Hours of Wind in This Direction" should read "Quarter-Hours of Wind in this Direction" as may be verified by summation of the values presented in Tables 4-1 and 4-2.

Table 2.

INVERTED WIND DIRECTION

FIRST WEEK

INVERTED HOURLY WIND DIRECTION

(direction wind blows towards or sector wind blows into)

Hour	March 28	March 29	March 30	March 31	April 1	April 2	April 3
0100	-	N	SW	NNE	NNE	WNN	S
0200	-	NW	SSE	ENE	WNW	WNW	SSE
0300	-	NW	SE	ENE	SW	NW	S
0400	S	WNW	SSW	NE	ESE	WNW	SE
0500	SW	WNW	W	NE	SSE	WNW	SE
0600	W	WNW	NE	NNE	S	WNW	S
0700	W	W	NNE	NE	NE	WNW	SSE
0800	WSW	W	S	ENE	E	W	NW
0900	NNW	WNW	SSE	NE	SE	WNW	SE
1000	ENE	SW	ESE	NE	SW	WNW	SE
1100	E	S	W	NE	S	WNW	SSE
1200	N	NNW	NE	NE	SSE	WNW	SE
1300	N	NNW	NW	ENE	SSE	WNW	SE
1400	NNE	N	NNE	ENE	SSE	NW	S
1500	NNE	SSE	WNW	NNE	SSE	WNW	ESE
1600	NNE	WSW	W	SE	SSE	W	NNW
1700	NNE	SSW	NW	SE	WSW	WNW	SE
1800	NNW	SSW	WNW	E	SW	WSW	SSE
1900	NNW	S	NW	ENE	W	WSW	S
2000	NNW	SSE	NNW	NNE	SW	S	SSE
2100	NNW	SSE	NW	NE	WNW	S	SSE
2200	NNW	S	NW	NE	NW	SSW	SSW
2300	NNW	W	NW	NNE	NW	WSW	SW
2400	NNW	N	NNE	SE	WNW	S	S

Based upon the wind direction (persistence) data in Table 3 and the locations of the dosimeters given in Tables A-1 and A-2 , it is possible to determine the number of hours that the wind blew in to a sector where there were no TLD's. By assuming that the wind direction measured at the site did not change with distance (time)* (invariant wind direction into a sector), it is possible to estimate the amount of time that the wind blew into areas that did not have a TLD or into areas that TLD's were placed in only after the majority of the radioactive releases had occurred. Table 4 shows the results of this analysis for the first three days following the accident (March 28 - March 31) and, Table 5 presents similar values for the period, March 28 to April 6, 1979, which corresponds to the period considered by the Ad Hoc Interagency Dose Assessment Group report.

Table 4 shows that 5 sectors (NE, SE, SSE, W, and NW**) had no TLD's located within 2 miles of the site and that the wind blew into these sectors approximately 40% of the time (37 hours out of 93 hours). There was a TLD located in the SSE sector at 2.3 miles (station 8CI). This is sufficiently close to the site to permit extrapolation of doses at locations closer to the site. The wind blew towards the SSE for

* This is a gross oversimplification as the direction does change beyond the site. However, this effect is less important for stations close (0-2 miles) to the site where most of the TLD's were located.

** Based on USGS topographic maps there are no permanent residences within 2 miles of the site in this sector. There are summer homes on adjacent islands. Except for one individual who was located on Hill Island (in the NNW sector), no other occupants of these summer homes have been identified.

Table 3. Comparison of Wind Direction Data from Hourly and Quarter-hourly Data

Wind into Sector		Hours of Wind Direction Based Upon Hourly Data											Based upon 15-minute* data for period 3/28-0700 4/6-1300
		3/28 0700	3/29	3/30	3/31	4/1	4/2	4/3	4/4	4/5	4/6 1300	TOTAL	
1	N	2	3							3	1	9	10
2	NNE	4		3	5	1				3	3	19	16.25
3	NE			2	9	1				1	1	14	-
4	ENE	1			6				1	4		12	10
5	E	1			1	1				5	5	13	10.25
6	ESE			1		1		1		6	3	12	-
7	SE			1	3	1		7		1		13	10.75
8	SSE		3	2		6		6	2			19	22
9	S		3	1		2	3	6	1			16	15.25
10	SSW		2	1			1	1	2			7	7.75
11	SW		1	1		4		1	1			8	7.0
12	WSW	1	1			1	3		4			10	11.25
13	W	1	3	3		1	2		6			16	-
14	WNW		4	2		3	13		5			27	27
15	NW		2	6		2	2	1	2			15	12.5
16	NNW	8	2	1				1		1		13	13.5
Total		18	24	24	24	24	24	24	24	24	13	223	173.5/223

*Tabulated by Pickard, Lowe, and Garrick, Inc. (consultants to Metropolitan Edison Co.)

Table 4. Geographical Area Coverage by Thermoluminescent Dosimeters During Initial Period of Accident: 0400 March 28, 1979 - 2400 March 31, 1979

Sector	Total Hours of Wind	Hours Monitored by Metropolitan Edison TLD's Located at					Additional Hours Provided By NRC TLD's Located at					Total Hours Monitored By Either (or Both) Types of TLD's					Total Hours Wind Was in Sector Without TLD's at				
	into sector	0-2 mi	2-5 mi	5-10 mi	> 10 mi	any distance	0-2 mi	2-5 mi	5-10 mi	> 10 mi	any distance	0-2 mi	2-5 mi	5-10 mi	> 10 mi	any distance	0-2 mi	2-5 mi	5-10 mi	> 10 mi	any distance
1 N	5	5	5			5						5	5			5	0	0	5	5	0
2 NNE	12	12				12						12				12	0	12	12	12	0
3 NE	11								4		4			4		4	11	11	7	11	7
4 ENE	7	7		7		7						7		7		7	0	7	0	7	0
5 E	2	2				2		1	1			2	1	1		3	0	1	1	2	0
6 ESE	1															0	1	1	1	1	1
7 SE	4			4	4	4		1					1	4	4	4	4	3	0	0	0
8 SSE	5		5			5							5			5	5	0	5	5	0
9 S	5	5*				5	*					5				5	0*	5	5	5	0
10 SSW	3	3				3						3				3	0	3	3	3	0
11 SW	3	3				3						3				3	0	3	3	3	0
12 WSW	2	2				2						2				2	0	2	2	2	0
13 W	8															0	8	8	8	8	8
14 WNW	6	6*				6	*					6*				6	0*	6	6	6	0
15 NW	8	*			8	8	*								8	8	8*	8	8	0	0
16 NNW	11	11*				11	*					11*				11	0*	11	11	11	0
Total Hours	93	56	10	11	12	73	0	2	5	0	4	56	12	16	12	79	37	81	77	81	16
Hours Unmonitored		37	83	82	81	20	-	-	-	-	-	37	81	77	81	16					

*There are no permanent residences in this sector segment.

Table 5. Geographical Area Coverage by Thermoluminescent Dosimeters During The Period 0400 March 28, 1979 - 1600 April 6, 1979

Sector	Hours of Wind	Hours Monitored by Metropolitan Edison TLD's Located at					Additional Hours Provided By NRC TLD's Located at					Total Hours Monitored By Either (or Both) Types of TLD's					Total Hours Wind Was in Sector Without TLD's at				
	into sector	0-2 mi	2-5 mi	5-10 mi	> 10 mi	any distance	0-2 mi	2-5 mi	5-10 mi	> 10 mi	any distance	0-2 mi	2-5 mi	5-10 mi	> 10 mi	any distance	0-2 mi	2-5 mi	5-10 mi	> 10 mi	any distance
1 N	9	9	9			9			4	4		9	9	4	4	9	0	0	5	5	0
2 NNE	19	19				19		7				19	7			19	0	12	19	19	0
3 NE	14								7		7			7		7	14	14	7	14	7
4 ENE	12	12		12		12						12		12		12	0	12	0	12	0
5 E	13	13				13		12	12			13	12	12		13	0	1	1	13	0
6 ESE	12							11			11		11			11	12	1	12	12	1
7 SE	13			13	13	13		10					10	13	13	13	13	3	0	0	0
8 SSE	19		19			19	14					14	19			19	5	0	19	19	0
9 S	17	17*				17	*	12	12	12		17*	12	12	12	17	0*	5	5	5	0
10 SSW	7	7				7		4				7	4			7	0	3	7	7	0
11 SW	9	9				9			6	6		9		6	6	9	0	9	3	3	0
12 WSW	10	10				10						10				10	0	10	10	10	0
13 W	17						9	9	9		9	9	9	9		9	8	8	8	17	8
14 WNW	27	27*				27	*	21	21			27	21	21		27	0*	6	6	27	0
15 NW	15	*			15	15	*		7			*		7	15	15	15*	15	8	0	0
16 NNW	13	13				13						13				13	0	13	13	13	0
Total	226	136	28	25	28	183	23	86	78	22	27	159	114	103	50	210	67	112	123	176	[illegible]
Hours Unmonitored		90	198	201	198	43	-	-	-	-	-	67	112	[illegible]	[illegible]						

approximately 5 hours, so that the time that the principal areas close to the site were without nearby TLD's can be reduced to 32 hours.

The nearest TLD's to the site in the SE and NW sectors were located at 9 miles and 15 miles, respectively. Although these doses can be extrapolated inward, the distances involved make such extrapolations less reliable than for shorter distances. Based on examination of topographic maps, no permanent residences were indicated within 2 miles of the site in the NW sector. The wind blew in this direction for approximately 8 hours. Allowing for the lack of residents in the close-in portion of the NW sector will reduce the time that close-in occupied areas were unmonitored to 24 hours. The principal close-in occupied areas where there was no close-in TLD and the wind persistence in these sectors are:

NE	11 hours
ESE	1 hour
SE	4 hours
W	8 hours
Total	24 hours

Table 4 shows that the few TLD's located beyond 2 miles result in these areas lacking TLD coverage for most (80%) of the initial 3-day period. This lack of more distant TLD coverage is more important as a source of uncertainty in the population collective dose estimates than it is for the ENO determination as the higher doses are expected to occur closer to the site.

Table 5 shows that the placement of the NRC TLD's on March 31st, primarily resulted in improved coverage beyond 2 miles. However, the NRC TLD's did not significantly improve the geographic coverage close to the site nor significantly improved the TLD area coverage for the first three days.

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15. SUPPLEMENTARY NOTES

16. ABSTRACT (200 words or less)

In July 1979, the Nuclear Regulatory Commission formally initiated the making of a determination as to whether or not the accident at the Three Mile Island Unit 2 (TMI-2) reactor on March 28, 1979 constituted an "extraordinary nuclear occurrence" (ENO). On August 17, 1979 the Commission directed that a panel comprised of members of the principal staff be formed to evaluate public comments, assemble information relevant to an ENO determination and report to the Commission its findings and recommendations. This staff report finds and recommends that the TMI-2 accident does not constitute an ENO.

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