August 31, 1982



UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

Before The Atomic Safety and Licensing Board

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| In the Matter of | ) | |
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| THE CLEVELAND ELECTRIC ILLUMINATING COMPANY, ET AL. | ) | Docket Nos. 50-440 50-441 |
| | ) | |
| (Perry Nuclear Power Plant, Units 1 and 2) | ) | |

APPLICANTS' ANSWER TO OHIO CITIZENS
FOR RESPONSIBLE ENERGY MOTION FOR
LEAVE TO FILE ITS CONTENTION 20

On August 9, 1982, Ohio Citizens for Responsible Energy ("OCRE") moved for leave to amend its petition for leave to intervene to add its Contention 20, entitled "Inadequate Consideration of Economic Consequences of Accidents." OCRE contends that the Draft Environmental Statement ("DES") for Perry Nuclear Power Plant ("PNPP") "is deficient because it has failed to include an assessment of the economic and societal disruption which would occur as a result of an accident at



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PNPP." Motion, at 1. More specifically, OCRE alleges that § 5.9.4.1.4.4 of the DES, which deals with the economic and societal impacts of accidents, is violative of the National Environmental Policy Act ("NEPA"), because it "gives only a cursory description of economic impacts of accidents." Motion, at 2. OCRE bases its contention entirely on NUREG/CR-2591, "Estimating the Potential Impacts of a Nuclear Reactor Accident" (April, 1982), which it contends identifies certain consequences which should have been considered by the NRC in the cost-benefit balance for PNPP.

The contention should not be admitted. OCRE has demonstrated no basis for its assertion that the DES's discussion of the economic and societal impacts of accidents is deficient under NEPA. NUREG/CR-2591 does not identify any oversight in the economic model used by the NRC to assess the economic consequences of accidents. To the contrary, NUREG/CR-2591 is no more than a limited experimental analysis of different economic modelling techniques, and can in no sense be viewed as an alternative or substitute for the more comprehensive economic model used for the DES. Simply put, the NRC Staff has met its statutory obligation to consider reasonably the economic consequences of postulated accidents at PNPP, and nothing cited by OCRE can provide a basis for concluding otherwise. See 10 C.F.R. § 2.714(b) (requiring basis and specificity).

I. The PNPP DES Considers the Economic and Societal Impacts of Nuclear Accidents

In order to demonstrate how the NRC has complied fully with its NEPA obligations, and why NUREG/CR-2591 does not undermine that compliance, it is necessary to describe briefly the economic model used by the NRC Staff, as well as the relationship of that model to NUREG/CR-2591.

In § 5.9.4.1.4.4 of the PNPP DES, the NRC describes its analysis of the economic and societal impacts of postulated accidents at PNPP. This analysis considers the following economic costs:

1. evacuation costs,
2. value of crops contaminated and condemned,
3. value of milk contaminated and condemned,
4. costs of decontamination of property where practical,
5. interdiction and mitigation costs of radioactive effluent fallout on the Great Lakes, and
6. indirect costs due to loss of use of property and incomes derived therefrom.

DES, at 5-54.

These costs are calculated for a wide range of accident scenarios and weather conditions, and are plotted with their corresponding probabilities. See DES, Figure 5.8, at 5-56.[1/] These accident consequences identified in the DES are derived from what is commonly known as the CRAC Code. The CRAC Code is described in detail in Appendix VI ("Calculation of Reactor Accident Consequences") to the Reactor Safety Study (NUREG 75/014, WASH-1400, 1975).[2/] Section 12 of Appendix VI describes the Economic Model used in the CRAC Code to determine the economic costs of particular accidents.[3/] As is readily apparent from reviewing the discussion contained in Section 12, the costs measured by the CRAC Economic Model are the costs identified in § 5.9.4.1.4.4 of the PNPP DES. See page 3, supra.

Despite OCRE's unsupported assertions to the contrary, the CRAC Economic Model is a highly sophisticated model of the economic consequences of nuclear accidents. As stated in

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1/ As discussed infra, the cost which must be "balanced" by the NRC is the risk of a particular accident times the consequence of that accident. Thus, for example, looking at Figure 5.8 of the DES, there is a probability of $10^{-8}$ per reactor year that an accident or accidents will occur which will have adverse consequences of $10^{10}$ dollars. The cost of that accident is $10^{2}$ dollars, or $100 per reactor year.

2/ The use of the consequence models described in the Reactor Safety Study is clearly established in the PNPP DES. See DES, at §§ 5.9.4.1.4.2 and 5.9.4.1.4.7; see also Appendix E.

The Reactor Safety Study has been rebaselined for the PNPP DES to incorporate the results of recent research and additional accident scenarios. See DES, Appendix E.

3/ A copy of Section 12 is attached.

Section 12, at 12-1, the purpose of the model is "to estimate the direct costs of measures to mitigate the effects of a reactor accident." These costs include direct evacuation, decontamination (or condemnation), and interdiction costs, plus certain indirect costs associated with the loss of property and income.[4/] As noted above, the economic impacts identified by the CRAC Economic Model are summarized in Figure 5.8 of the PNPP DES, and plotted with their corresponding probabilities.

OCRE's concerns regarding the economic impacts analysis in the PNPP DES are based wholly on what it apparently perceives to be inconsistent findings in NUREG/CR-2591. The simple fact of the matter, however, is that NUREG/CR-2591 is but part of an ongoing NRC reassessment of its economic modelling techniques, and does not, of itself, undermine or contradict the CRAC Economic Model.[5/]

As with the CRAC Economic Model, NUREG/CR-2591 is based on other inputs from the CRAC Code, such as source terms and atmospheric dispersion.[6/] However, in assessing the

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4/ As stated in Section 12, the loss of income resulting from temporary unemployment is considered in the Economic Model. *See* pages 12-2 and 12-7.

5/ Over the past several years the NRC has been reassessing various parts of the CRAC Code. One of the areas under review is the economic modelling techniques used to assess the economic impacts of nuclear accidents. NUREG/CR-2591 is part of that review.

6/ *See* NUREG/CR-2591, at 55 n.3.

economic impacts of these inputs, NUREG/CR-2591 uses different modelling techniques. In particular, there are two principle differences between the methodology used in NUREG/CR-2591 and the CRAC Economic Model. First, NUREG/CR-2591 uses demand-driven and supply-constrained input/output models rather than the direct cost model of the CRAC Code.[7/] Second, NUREG/CR-2591 does not identify its costs in terms of dollars, but rather in terms of the associated lost employment.[8/]

NUREG/CR-2591 is in no sense an alternative or substitute for the economic impact assessment described in the PNPP DES. The economic analysis performed in NUREG/CR-2591 is far more limited in scope. Unlike the PNPP DES, which determines the economic impact of a number of different accident scenarios for all wind vectors, NUREG/CR-2591 analyzes only the worst-case accident scenario (SST1) for the worst-case wind vector (SW). Most critically, NUREG/CR-2591 makes no attempt to define the probability associated with the identified consequences.

These differences between the CRAC Economic Model and NUREG/CR-2591 are not an indictment of either economic model.

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7/ See NUREG/CR-2591, at 5-23.

8/ See NUREG/CR-2591, at 1 ("The model estimates the first-year industry-specific losses in employment associated with the decrease in regional industrial output caused by the contamination."), and Tables 7.7 and 7.9 (Private Sector Employment Losses).

Rather, they follow from the different purposes of the models. The CRAC Economic Model, as used for the PNPP DES, identifies the total economic cost (that is, probability times consequence) of accidents at PNPP. NUREG/CR-2591, however, is an experimental modelling of the economic consequences of a particular accident scenario, using different modelling techniques (input/output rather than direct cost) and a different way of measuring impact (lost employment rather than dollars).

In this regard, it should be observed that economic modelling is not a definitive science. Modelling techniques are constantly reviewed and refined in an effort to obtain greater precision. Undoubtedly, the NRC will continue to review and refine the CRAC Economic Model as even more sophisticated modelling techniques are developed. In the process, the NRC will almost certainly consider a number of different methodologies, rejecting some altogether and incorporating others. OCRE has not, however, demonstrated any basis for concluding that the CRAC Economic Model does not reasonably assess the economic impacts of postulated accidents at PNPP.

In reviewing the significance of NUREG/CR-2591, it also is worth noting the probability associated with the accident scenario for PNPP (the SST1 source term and SW wind vector).[9/] The SST1 accident scenario involves the failure of

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9/ The NRC Staff, in making its NEPA analysis, is directed to assess <u>both</u> the consequences and probabilities of accident

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the emergency safety systems, resulting in severe breach of the containment and corresponding releases. See NUREG/CR-2591, at 55 n.4; NUREG-0771, "Regulatory Impact of Nuclear Accident Source Term Assumptions," at 8 (June, 1981) (Pasedag, Blond and Jankowski). This is the same source term as the TC gamma prime identified in the PNPP DES. See NUREG-0773, "Reactor Accident Source Terms: Design and Siting Perspectives," at 96 (draft dated March, 1982) (TC gamma prime designated as SST1).10/ The probability associated with the TC gamma prime source term for PNPP is $2 \times 10^{-6}$ per reactor year. See DES, Table 5.8, at 5-47.

The "worst case" wind vector used by NUREG/CR-2591 is a wind blowing in the southwest direction.11/ The probability of encountering such a wind at PNPP is approximately $5 \times 10^{-2}$. See PNPP Environmental Report -- Operating License Stage, Figure 2.3-5.12/ The total probability of the accident

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scenarios. See PNPP DES § 5.9.4.1.4.6; Commission Statement of Interim Policy, "Nuclear Power Plant Accident Considerations Under the National Environmental Policy Act of 1969," 45 Fed. Reg. 40101 (June 13, 1980).

10/ NUREG-0773 is scheduled to be published imminently. The section discussing SST1 and TC gamma prime is entitled "Generic Source Term Development."

11/ To the extent that NUREG/CR-2591 suggests that the SW wind vector is a "likely" vector for PNPP, the NUREG is wrong. See note 12, infra.

12/ In reading the annual wind roses of Figure 2.3-5, it should be noted that the wind roses measure the wind blowing in

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scenario described in NUREG/CR-2591, therefore, is approximately $10^{-7}$ ($2 \times 10^{-6}$ times $5 \times 10^{-2}$) -- about one in ten million reactor years. Thus, even using the highest economic impact consequence in the PNPP DES -- approximately $10^{10}$ dollars[13/]--the total cost of the postulated accident which must be balanced by NRC comes to only about $1,000 per reactor year (\$$10^{10}$ times $10^{-7}$), a trivial amount compared to the other costs and benefits considered by the NRC in making its NEPA analysis.

## II. The NRC Has Fulfilled Its Statutory Obligations Under NEPA

OCRE contends that the PNPP DES is deficient because it does not consider fully the economic consequences of nuclear accidents at PNPP. Specifically, OCRE complains that the DES "gives only a cursory description," and thus does not provide a sufficiently detailed statement of the economic consequences.

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the direction of PNPP. The wind vectors in NUREG/CR-2591, however, refer to the direction the wind is blowing away from PNPP. NUREG/CR-2591, at 34 n.1. Thus, to determine from Figure 2.3-5 the frequency with which the wind blows away from PNPP to the southwest, one must read the frequency with which the wind blows into PNPP from the northeast. That frequency is approximately 5% on an annualized basis.

13/ *See* DES, Figure 5.8.

OCRE fundamentally misappreciates the type of environmental impact statements required by NEPA.

The adequacy of an environmental impact statement (EIS) is judged by a rule of reason. That rule of reason "requires only a reasonably thorough discussion of the significant aspects of the probable environmental consequences." Columbia Basin Land Protection Ass'n v. Schlesinger, 643 F.2d 585, 592-93 (9th Cir. 1981) (citations omitted). The rule of reason does not impose "a per se rule requiring detailed discussion of overall environmental effects." Id. at 593. Rather, it requires only a discussion designed "reasonably to set forth sufficient information to enable the decision-maker to consider the environmental factors and to make a reasoned decision." Id. As stated by the court in North Slope Borough v. Andrus, 642 F.2d 589 (D.C. Cir. 1980), an EIS "need not be exhaustive to the point of discussing all possible details on the proposed action but will be upheld as adequate under the 'rule of reason' if it has been compiled in good faith and sets forth sufficient information to permit a reasoned decision after balancing risks against benefits." Id. at 600 n.47 (quoting County of Suffolk v. Secretary of Interior, 562 F.2d 1368, 1375 (2d Cir. 1977)). There can be no doubt whatsoever that the rule of reason must be applied by licensing boards as the applicable standard of review under NEPA. See Public Service

Company of Oklahoma (Black Fox Station, Units 1 and 2), ALAB-573, 10 N.R.C. 775, 778-79 (1979).14/

It thus is clear that, under NEPA, an agency is free to choose the means for assessing the environmental impacts of a proposed action so long as those means are reasonable and used in a good faith effort to comply with NEPA. CCRE cannot seek to expand the NRC's statutory obligations beyond what is required by NEPA. But that is precisely what this contention attempts to do. So long as the NRC has considered the involved impact in a reasonable manner, there can be nothing to litigate for the simple reason that the NRC has complied fully with its statutory obligations.

As previously noted, the CRAC Economic Model is a highly sophisticated model designed to measure the economic consequences of nuclear accidents. So long as the NRC has compiled and used the Economic Model in a reasonable and good faith effort to assess such costs, the NRC is in full compliance with NEPA. The fact that the NRC is reviewing other modelling techniques cannot, of itself, be a basis for concluding that there is some fundamental deficiency in the CRAC Economic Model.

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14/ The Appeal Board in Black Fox expressly rejected the argument that the rule of reason should be limited to the evaluation of alternatives. 10 N.R.C. at 779 n.15.

Moreover, as also noted above, NUREG/CR-2591 cannot undermine the PNPP DES economic analysis for the reasons that NUREG/CR-2591 is far more limited in scope, measures the economic impacts only in terms of lost employment, and provides no analysis of the probability (or cost) associated with the identified consequences. See page 7-9, supra. Simply put, there is no foundation for finding that NUREG/CR-2591 identifies some oversight in the CRAC Economic Model, or identifies consequences more severe than those computed by the CRAC Code.

As for OCRE's argument that the PNPP DES is deficient because it is not sufficiently specific, it is clear from reading the appropriate sections in the DES, and referencing the list of citations at the end of Chapter 5, that the DES cites all relevant supporting documents. Specifically, the DES expressly states that its probabilistic and risk assessment discussions are based on the methodology described in the Reactor Safety Study (WASH-1400). See PNPP DES §§ 5.9.4.1.4.2 and 5.9.4.1.4.7; see also Appendix E.[15/] As noted, the CRAC Code, including its Economic Model, are described in detail in Appendix VI of that Study. In this regard, it is well settled

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15/ Section 5.9.4.1.4.2 of the PNPP DES also cites NUREG-0340, "Overview of the Reactor Safety Study Consequences Model" (October, 1977), in which the CRAC Economic Model is discussed (at pages 22-25 and 36).

law that it is "clearly permissible for [an EIS] to incorporate by reference previous studies and supporting documents so long as that material . . . is available and accessible to the public and reviewing agencies." Randolph Civic Ass'n v. Washington Metropolitan Area Transit Authority, 469 F.Supp 968, 970 (D.C. D.C. 1979) (citing Sierra Club v. Adams, 578 F.2d 389, 394 (D.C. Cir. 1978); Trout Unlimited v. Morton, 509 F.2d 1276, 1284 (9th Cir. 1974); Philadelphia Council of Neighborhood Organizations v. Coleman, 437 F.Supp. 1341, 1366 (E.D. Pa. 1977), aff'd, 578 F.2d 1375 (3d Cir. 1978)).16/

In sum, all NEPA requires is that the NRC in good faith reasonably assess the economic impact of nuclear accidents. The CRAC Economic Model is such a reasonable assessment. OCRE's citation to NUREG/CR-2591 does not in any way support a conclusion that NRC's use of the CRAC Economic Model is unreasonable and, therefore, violative of NEPA. Because OCRE has not demonstrated any basis from which it could be found that the NRC has failed to assess reasonably the economic consequences of an accident, OCRE has failed to identify a litigable issue.

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16/ The Reactor Safety Study has been available to the public since 1975.

## III. Even If the Licensing Board Agrees with OCRE, It Should Amend the Final Environmental Statement Pro Tanto

OCRE contends that the PNPP DES is deficient because it does not consider the specific economic consequences identified in NUREG/CR-2591. For the above stated reasons, Applicants believe this contention to be without basis. However, should the Licensing Board agree with OCRE, Applicants would urge the Licensing Board simply to amend the PNPP Final Environmental Statement pro tanto to include consideration of the specific economic consequences identified in NUREG/CR-2591. See 10 C.F.R. § 51.52(b)(3); see generally Allied-General Nuclear Services (Barnwell Nuclear Fuel Plant Separations Facility), ALAB-296, 2 N.R.C. 671, 680 (1975). Such a resolution would be both simple and efficient,[17/] as well as comply fully with the requirements of NEPA.

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17/ In light of the extremely low probability of the accident scenario of NUREG/CR-2591, see pages 7-9, supra, the total additional cost, if any, that would need to be considered by the NRC, would probably be less than a thousand dollars per reactor year. The cost of litigating this issue, however, certainly will run into the tens of thousands of dollars. There is little logic in expending such sums simply to conclude that the NRC should include an almost trivial additional amount in its environmental cost/benefit analysis for PNPP.

## IV. The Motion Should Be Denied As Untimely

The Contention is untimely under 10 C.F.R. § 2.714(a)(1), and, as such, cannot be admitted.

With regard to the first of the listed factors -- whether OCRE has demonstrated "good cause" for its tardy filing -- it should be noted the CRAC Economic Model has been available to the public since 1975. To the extent that OCRE is alleging that the methodology of the Economic Model is deficient, it has known or should have known of the model's methodology since well before its intervention in this proceeding.

As for the other factors of 10 C.F.R. § 2.714(a)(1), OCRE has an alternative means to protect its interests through comments to the NRC Staff on the PNPP DES. OCRE's claim that "[c]ommenting on the DES is not seen by OCRE as an effective means by which to address significant matters," Motion, at 2, is no more than a bootstrap attempt to excuse its failure to file comments on the DES. Also, in light of OCRE's failure to appreciate the differences between the CRAC Economic Model and NUREG/CR-2591, OCRE's participation cannot reasonably be expected to assist in developing a sound record. Finally, to the extent that the Licensing Board might admit the contention for litigation, Applicants believe that at this late date admission of the contention will delay the proceeding. Indeed, OCRE concedes as much. See Motion, at 3.

For the stated reasons, CCRE's motion for leave to amend its petition for leave to intervene should be denied.

Respectfully submitted,

SHAW, PITTMAN, POTTS & TROWBRIDGE

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Section 12

# Economic Model

## 12.1 INTRODUCTION

The adverse health effects that could result from a major reactor accident would originate from the airborne radioactive material and from the material which would be deposited in the environment. The principal action taken to minimize the harmful effects due to the airborne material would be to evacuate the people situated in the path of the radioactive cloud.

Measures to mitigate the effects of radioactive material which had been deposited on the ground could include condemnation of contaminated crops, interdiction of land (prohibition or restriction of its use) and decontamination of land and structures. This chapter describes the costs of these mitigating measures and the economic consequence model for estimating these costs.

The scope of the economic consequence model is defined in subsection 12.1.1. Section 12.2 contains a conceptual outline of the model. Sections 12.3 and 12.4 describe in detail how the costs are estimated in the model. The final section summarizes the values assigned to important parameters of the model.

It is important to the understanding of the economic effects of a reactor accident to appreciate that these effects are partly determined by the standards used to define the boundaries of the interdiction and contamination zones. Ideally, these standards would be chosen so that the total cost of interdiction (including the "cost" of adverse health effects accompanying the permitted uses) would be minimized. Although this study does not assess the dollar cost of human exposure to radiation, these costs exist nevertheless, and will be perceived by the people affected. If an interdiction plan is designed on the basis of excessively tolerant radiation standards, excessive biological costs could be incurred. On the other hand, if the standards are over-stringent, the cost of mitigating measures could be excessive.

One of the principal parameters used in the consequence model for estimating the costs associated with a hypothetical release of radioactive material is the population density as a function of distance and direction from the reactor. For each release analyzed, the consequence model is used to calculate the total population affected and the extent to which this population would be affected. These calculated results depend on the weather conditions assumed to prevail at the time of the accident, and then subsequently, on the population distribution about the particular site analyzed.

For the computation of property damage, it was necessary to use some data obtained from averages over whole states or the entire nation (e.g., descriptions of buildings, fraction of land occupied by buildings, characteristics of apartment houses, etc.).

### 12.1.1 SCOPE OF THE MODEL

The model is intended to estimate the direct costs of measures to mitigate the effects of a reactor accident. These costs would include the cost of managing a possible evacuation, the cost of temporary accommodation for the evacuees, the value of any goods that might be condemned, the decrease in value of interdicted property, and the cost of decontaminating property.

A distinction should be made between this direct cost and the national cost of mitigating measures. The direct cost is necessarily larger than the national aggregate or "resource" cost because it includes only losses and is not offset by any of the gains that may result. While the nation as a whole would be assumed to obtain no economic gains from the mitigating measures, certain individuals might do so. For example, if a community were dispersed as a mitigating measure, its children would go to schools in other areas. As a result, some unemployed teachers might become employed, offsetting the lost earnings of the children's former teachers over the period during which they relocate and seek new jobs. The relocated teachers' lost earnings would be included in the assessment of direct costs, but an assessment of national cost would reduce this amount by the added earnings of the previously unemployed teachers.

## 12.2 CONCEPTUAL OUTLINE OF THE ECONOMIC CONSEQUENCES MODEL

The cost of mitigating measures would depend on the specific measures employed and the extent of the areas to which they were applied. The measures employed would depend on the nature of the radioactive contamination, the human exposure associated with normal activity (land use) in the area and the standards for acceptable exposure. The nature of the contamination would depend on the mode of the reactor accident, meteorological conditions during release and passage of the radioactive "cloud", and local geography.

The model treats mitigating measures in relation to two separate exposure phases, acute and chronic. Measures for mitigating, or actually, for preventing, acute exposure are assumed to be initiated on the basis of a forecast of the path of the radioactive cloud. Measures for mitigating chronic exposure would be instituted following a survey to determine the pattern of contamination that had actually occurred.

### 12.2.1 ACUTE EXPOSURE PHASE

The model "forecasts" the acute exposure area by reference to an assumed emergency plan. According to the plan, each reactor is at the center of two circles of radius 5 miles and 25 miles, respectively. The circles are divided into 16 segments as shown in Figure VI 12-1. For an accident leading to a core melt, the downwind segment of the large circle, and one-half of the nearest segment on each side of the down-wind segment and the entire inner circle are assumed to be evacuated.

It is assumed that after an accident during the local growing season, crops and milk produced from animals feeding on pasture within the contaminated area may be condemned. For an accident during the local dormant season, crops would not be exposed. Since milk is presumed to be produced from uncontaminated feed, it, too, would be uncontaminated.

The cost of acute phase mitigation measures is computed as the sum of the following:

- Evacuation cost
- Value of crops condemned
- Value of milk condemned.

If the reactor accident were less severe than a core-melt, evacuation of people would not take place. Depending on the magnitude of the radioactivity release and meteorological conditions, some milk and crops could be condemned.

### 12.2.2 CHRONIC EXPOSURE PHASE

The consequence model provides a calculation of the area of chronic exposure hazard, as explained in sections 8.3 and 11.1.1.3. Where calculated radiation levels are high (relative to an assumed standard) the mitigation countermeasure is taken to be interdiction: continued human activity in the area is forbidden. Where calculated radiation levels are above the standard, but low enough that decontamination becomes feasible, there is a choice between decontamination and interdiction. The costs of chronic exposure mitigation are computed as the cost of decontamination (where feasible) plus cost of interdiction (where decontamination is not feasible) (see section 11.2.2 for details on decontamination and interdiction). The cost of interdiction is computed as the sum of the following costs:

- Loss in value of public and private property
- Loss of income during period of relocation and temporary unemployment.

## 12.3 COSTS OF ACUTE EXPOSURE MITIGATING MEASURES

The costs resulting from acute exposure mitigating measures would include:

- Costs of evacuation and temporary food and shelter

- Value of condemned crops and other farm products

Table VI 12-1 shows unit costs for evacuation as estimated in an EPA study (Hans and Sell, 1974) of 64 evacuations following disasters in the United States. The study reports that cost records of these disasters are fragmentary and inconsistent. However, using some of the records, a knowledge of how evacuation costs are incurred, and general data on prices and labor rates, the EPA study constructed the estimates shown.

The EPA study states that the number of personnel required to supervise an evacuation ranges from 0.4 to 5% of the number of evacuees and averages 2%. The evacuation costs appear to include the cost of securing property, although the incidence of looting in disasters is reported to be low. The EPA estimates do not include any costs for unpaid assistance. Nor do they appear to include costs of special equipment and supplies, although it is recognized that these costs are incurred.

On the assumption that 80% of evacuees are transported by private vehicles and obtain commercial accommodation, 20% are transported in buses and accommodated in mass care facilities, and prices have increased about 15% since the EPA study, the unit daily cost would be $13.50 per evacuee for food, shelter, evacuation personnel, and the cost of transportation. The total of these costs for an evacuation lasting about a week would therefore be $54 per day for a family of four.

#### 12.3.2 CONDEMNATION OF AGRICULTURAL PRODUCTS

Farm losses would include the value of condemned milk and crops. Current price data are readily available and need not be quoted here.

To compute the crop losses following an accident the model accounts for deposition of radioactive material on the crops as a function of distance from the reactor and of weather conditions. The diminishing strength of this deposited radioactivity from the time of contamination to the time when the crops would normally be harvested is then calculated. If the contamination level calculated for the time of harvest is within the acceptable standard, the crops are assumed to be harvested and therefore not lost.

### 12.4 CHRONIC EXPOSURE - COSTS OF DECONTAMINATION AND INTERDICTION

In the chronic exposure phase, mitigating measures are assumed to consist of either land interdiction (including relocation of residents), decontamination, or both. The following section discusses the considerations involved in the calculation of the economic impact of each type of measure.

#### 12.4.1 COSTS OF DECONTAMINATION

##### 12.4.1.1 Farmland

Whether or not farmland should be decontaminated, and the best method to use, would depend on the intensity and decay rate of the contamination, on climate, on physical characteristics of the land, and on how the land is utilized. Table VI 12-2 summarizes the estimated unit costs and effectiveness of three decontamination techniques. The cost estimates are derived from the updated costs of construction (Mohon, 1974; Robert Snow Means Co., 1974).

Some technical limitations on the choice among decontamination methods are suggested by Table VI 12-2. Deep plowing would not be suitable for orchards. Obviously, removal of the trees would increase the cost of the decontamination operations; but it would also increase the loss, because several years are required to develop a fully productive tree.

In the past a farm commonly served as both a residence and a productive enterprise, and this is still often the case. However, in recent decades specialization, mechanization, and the development of a dense network of rural roads has made it feasible, and not unusual, to live in a town and to work a farm several miles away, or even to work a farm consisting of several parcels separated by considerable distances. Therefore, decontaminating a farm could be wholly for the purpose of protection of farm workers, or also partly for the protection of residents. If contamination were below a certain level, it might be satisfactory to decontaminate only the area surrounding the residence or to use a technique with a high decontamination factor for the residential area and a technique having a lower factor (and cost) for the remaining land.

12.4.1.2 Unit Costs for Decontaminating Developed Property

The costs of decontaminating developed property are estimated on the assumption that two alternative methods would be used, depending on the degree of decontamination required to meet the radiation exposure standards. If a decontamination factor of 2 would suffice (50% reduction in contamination), the method would consist of replacing lawns and firehosing roofs and paving. If a decontamination factor of 20 were required (95% reduction in contamination), lawns, paving and roofing would be replaced. The unit costs of these operations are estimated to be:

| | Cost per square foot |
|---|---|
| Replace lawns | $0.11 - 0.14 |
| Replace paving | $0.15 - 0.30 |
| Replace roofing | $0.50 - 2.0 |
| Firehose paving | $.05 |
| Firehose roofing | $.05 |

These costs include the costs associated with the preparation of a disposal site and restoration of the decontaminated properties.

12.4.1.3 Housing

The cost of decontaminating a residence depends on the degree of contamination sought and such additional factors as the type and size of structure, as well as the areas of surrounding lawns, driveways and streets. As a general rule, the closer a residence is to the "center" of the c[illegible]e., metropolitan area) and the larger the population of that city, the higher [illegible] the residential density. Thus, in the central areas of large cities, residences tend to be apartments or houses occupying very small sites. Suburban residential development consists predominantly of single family units and both the site and the surface area occupied by the structure tend to be larger than in central areas. Similarly, suburban apartments tend to use more land per household than central city apartments. Ex-urban and rural development is even less dense than suburban. Thus, the costs of residential decontamination would depend partly on distance from a city center and the size of the city. It will be useful, therefore, to consider the costs of residential decontamination for a range of development densities.

Table VI 12-3 shows estimates for decontaminating two single family residences where the development densities are one residence per acre and five residences per acre, respectively. A density of one unit per acre is typical of rural areas and usually reflects a public health standard for the minimum area for septic field drainage. The cost of decontamination is estimated to be in the range $1370 to $1710 per capita to obtain a decontamination factor (DF) of 2, and in the range $1860 to $3590 to obtain a DF of 20.

A typical urban lot size for single family dwellings is one-sixth of an acre and corresponds to a development density of about five units per acre (allowing for streets). Table VI 12-3 estimates the decontamination cost of a structure occupying 2000 square feet to be in the range $320 to $370 per capita for a decontamination factor of 2, and in the range $560 to $1630 per capita to achieve a decontamination factor of 20.

It is assumed that in the typical apartment development, 30% of the area is occupied by structures and the remainder (which includes streets) is paved. It is assumed that each apartment occupies 1200 square feet (including corridors, etc.); that 3.2 persons live in each apartment; the number of apartments per floor is 10.9; and the number of people per floor is 34.8, or 31 if 90% occupancy is assumed. If three floors of apartments are assumed, the decontamination cost becomes about $30 per person for a DF of 2, and in the range $140 to $420 per person to achieve a DF of 20. For a six-floor structure, these per capita costs would be halved. These results are summarized in Table VI 12-4.

12.4.1.4 Commercial, Industrial, and Public Property

The costs for decontaminating commercial, industrial, and public property may be constructed in the same manner as for residences, on the basis of cost estimates for decontamination of roofs, paving and lawns

If it is assumed that an industrial or commercial lot is 50% occupied by a structure and the remainder is paved, the decontamination cost becomes about $2200 per acre for DF=2, and in the range $14,000 to $56,000 per acre for DF=20.

The proportion of the lot occupied by structures depends primarily on its location and the industrial or commercial activity for which it is used. Activities requiring large areas for shipping and receiving or for parking cannot usually support the high price of land in the central areas of large cities and are located in rural or suburban areas. Activities which are carried out in densely developed areas usually are those which can obtain a high level of land utilization, usually through use of high-rise structures. Table VI 12-5 shows the land use per 100 population for commercial, industrial and public purposes in a sample of central cities and satellite cities of various sizes. In general, land is more intensively used in small central cities than in large. That such tendencies are not observed in the data for satellite cities probably is a reflection of their lower land values which do not provide as strong incentives for sparing use of land.

In rural areas, the land use is expected to be less intensive than in urban areas, but the level of commercial and industrial activities is small. Large national parks exist in rural areas, but the level of utilization is so low that the cost of exposure by radiation would not be significant.

Weighting the data in Table VI 12-4 by the distribution of U.S. population among the urbanized areas leads to the averages shown in Table VI 12-6.

If the commercial and industrial land is 50% occupied by structures and 50% paved for streets, parking lots and driveways, the cost of decontamination of these areas would be about $21 per capita for DF=2 and in the range $140 to $490 for DF=20. Assuming parks to be mainly lawn with surrounding streets, the per capita cost would be in the range $26 to $33 for DF=2 and $31 to $46 for DF=20.

Public areas include a variety of buildings, such as schools, government buildings, and sewage plants. In general, the land use in these areas is less intensive than in commercial and industrial areas. On the assumption that public land is 30% occupied by structures and the remainder is paved for streets and parking lots, the decontamination cost would be about $2200 per acre for DF=2 and in the range $11,000 to $35,000 per acre for DF=20. The per capita cost would be about $40 for DF=2 and in the range $200 to $640 for DF=20.

Table VI 12-7 is a summary of the cost estimates for decontamination of commercial, industrial, and public property.

12.4.1.5 Summary of Decontamination Costs

Farmland

A reliable estimate would consider the level of contamination for each area and select from among the decontamination measures and measures to move individuals to limit their exposure. The costs are likely to be in the range zero to $5000 per acre. When higher costs would be incurred, abandoning the land is likely to be the preferred measure. The model assumes that surface soil burial by deep plowing would be used for tilled land and grazing land, and scraping surface soil would be used for orchards. The costs are weighted by the area's share of farmland use in the United States. The weighted cost is $230 per acre. The overall decontamination factor is about 20.

Developed Land

For land used for residential, commercial, industrial, and public purposes, the costs would depend very much on how intensively the land is used, and this in turn would depend on the size of the urban area and where the affected area is located within it. The model estimates the cost on a per capita basis.

The cost estimates for decontamination of residential property in Table VI 12-4 is weighted by the total U.S. housing statistics of location and housing type. The weighted cost is in the range \$530 to \$640 per capita for DF=2 and in the range \$780 to 1830 per capita for DF=20. The cost estimates for decontamination of commercial, industrial and public properties are shown in Table VI 12-7. The total cost estimates for developed land are derived by including residential land costs with the figures of Table VI 12-7 and are in the range \$620 to \$730 for DF=2 and in the range of \$1150 to \$3000 for DF=20. The model uses \$700 for DF=2 and \$2000 for DF=20.

### 12.4.2 INTERDICTION AND RELOCATION

If land were to be interdicted, the occupants and owners would bear two kinds of costs--loss of productive use of the land and its improvements (structures and other fixtures), and the costs of relocation. The general principles for calculating the cost of interdiction are the same for most types of land. The costs of relocation are not so easily calculated because of a scarcity of data.

#### 12.4.2.1 General Principles for Calculating Cost of Interdiction

The property is assumed to have a market value and this value may be considered to be the sum of the value of the land, plus the value of the improvements. The value of the property to the owner is the value of the uses to which he can put it, or the amount that it could be sold for, whichever is higher. However, in this discussion the latter will be assumed, i.e., its value is the market value.

If the property is interdicted for T years, it is assumed that no use can be made of it for that time. This does not mean that the land has lost all value. The property would be valueless only if either it were permanently interdicted, with no possibility of the interdiction order being canceled; or, the fixed cost of owning it were more than any possible future benefit to the owner. The likely situation is that it will be potentially useful at the end of T years.

Let $V_L$ be the value of the land before interdiction and let $V_I$ be the value of the improvements. Assume that the property could be as valuable in real terms after T years as before interdiction if it were in the same condition.

Although the condition of the land is assumed to be essentially unchanged, the improvements will have depreciated because of functional obsolescence and lack of maintenance. Let d be the annual rate of depreciation. Then T years later the value of the property will be:

$$V_T = V_L + \exp(-Td)\ V_I.$$

There is a cost associated with holding the property for T years. If it were sold at any earlier time, the proceeds could be invested at interest, or existing loans could be reduced with a consequent saving in interest costs. In addition, it is assumed that the property would continue to be subject to real estate taxes in proportion to its value. Let r be the interest rate on money plus the property tax rate. Then the value of the property immediately after interdiction (PV) is its value at time T reduced by the cost of holding it until then:

$$PV = \exp(-rT)\ V_T$$

$$= \exp(-rT)[V_L + \exp(-Td)\ V_I].$$

Let the value before interdiction be

$$V_o = V_L + V_I$$

and let the value of improvements as fraction of total value be

$$a = V_I/V_o.$$

Then

$$PV = \exp(-rT)[(1 - a)\ V_o + a\ \exp(-Td)\ V_o]$$

$$= \exp(-rT)[(1 - a) + a\ \exp(-Td)]\ V_o.$$

To see what this means in practical terms, assume that the interest rate is 9% and the property tax is 3%. Then r = 0.12.

Let improvements depreciate at 20% per year to reflect cost of maintenance. Then

$d = 0.20$ and $PV = \exp(-0.12T)[(1 - a) + a \exp(-0.120T)] V_o$.

For residential, business and public property, the improvements are usually valued at about 70% of the total. For farm property, improvements may be valued at about 25% of the total. Table VI 12-8 uses this equation for PV to show the effect of interdiction periods of 1, 5, 10, and 20 years on properties whose values before interdiction were 100 units. The only parameter in the equation whose value could be seriously in error is the depreciation rate on improvements. The value of 20% is judged to be appropriate in view of the lack of maintenance during interdiction. Where property is maintained, depreciation is usually judged to be in the range 3 to 5%.

The crucial assumption in the calculation is that land will regain its previous value (adjusted for inflation) when interdiction ends. However, if a community were interdicted it would become a ghost town and it might or might not be restored. Because of the deteorioration of structures, the former is certainly a probable outcome. On the other hand, the infrastructure of utilities, sewers, streets and roads could be attractive to a developer who might find that by purchasing the entire stock of real estate in the community he could reduce the deterioration or redevelop the area to advantage, exploiting the infrastructure and any locational advantages. The valuation of farms in these calculations inspires more confidence. Unlike residences and commercial or industrial establishments, a farm's value is not dependent on its close proximity and ease of access to other establishments which might not be restored after interdiction. The important locational requirement of a farm is access to markets for its supplies and its products, which would probably not be changed by a period of interdiction.

The valuation of loss by the calculation above could be refined considerably to reflect differences in the nature of holding costs for various periods of interdiction. For example, if interdiction were for no more than 5 years the depreciation rate could be judged too high, but additional carrying costs would be incurred. If a farm were interdicted for a short period, say a few months, the owner would not relocate and would continue to hold stocks and movable equipment, although they could not be used. The additional carrying costs would include interest, insurance and possibly personal property taxes. For a longer period, say 5 years, stocks and movable equipment would probably be relocated or sold, but insurance on the structures would probably be kept in force. Thus, while the depreciation rate of 20% may be high for shorter interdiction periods, the resulting bias is offset by the absence of other holding costs. Whether the net result is a high or low estimate of loss for shorter interdiction periods has not been ascertained.

12.4.2.2 Relocation Costs

In the event that land and structures come to be interdicted, the people must be relocated in some permissible area. The cost of such a relocation is made up of two factors — loss of income and moving costs.

Loss of Income

Loss of income is subdivided into the parts associated with the residential sector and the corporate business sector. The residential or household sector is made up of wages and salaries, proprietor's income, and rental income. Excluded from this category are types of income which would not be affected by interdiction and relocation, such as interest from personal savings accounts, dividends, unemployment insurance, etc. The U.S. average for this type of income is $4400 per capita per year[1].

[1] This number is an estimate for 1975 (Statistical Abstracts of the United States) using 1972 data and an 8% increase per year.

This income loss would only be applicable during the period of resettlement. This study assumes that this period lasts 90 days, allowing the person time to resettle and to find a job, if unemployed. This number is based on information that the average actual duration of unemployment benefits given from 1960 to 1972 was 11.4 to 14.3 weeks (80 to 100 days). The household loss of income therefore would be about $1100 per capita.

Loss of income for corporations would partly be the result of loss of profits and partly the result of continued interest on debts, and depreciation of equipment. In 1974 these categories amounted to 385 billion dollars, with the profits being taken before tax. This value amounts to $1850 per capita per year. In this study it was assumed that corporate relocation took on the average six months to complete. This was chosen with the knowledge that although some businesses require much longer than 6 months to relocate, others take significantly less than this. Thus the cost for relocation due to loss of income is $940 per capita.

Moving Costs

The costs incurred in moving people to a new area are made up of household costs and business costs. The shipping of 10,000 pounds of family belongings by commercial movers costs $1100 to $1400 for a distance of 50 to 100 miles. Since the average family in the U.S. has 3.2 members, this cost would average $340 to $440 per capita. A value of $400 per capita was used in this study.

Estimates of the cost of moving a business are not so readily available. In this study the cost was assumed to be 10% of the value of the equipment and inventory. The value of such equipment and inventories has been placed at 850 billion dollars in 1975, or $4200/per capita. The moving cost is therefore estimated to be about $420 per capita.

The cost of moving the public sector (i.e., governmental agencies, etc.) must also be accounted for. Once again, it is assumed that the moving cost is 10% of the value of equipment and inventory. The value of such items was placed at 111 billion dollars in 1975, or about $500 per capita. The moving cost is therefore about $50 per capita.

The total per capita moving cost is the sum of the cost from each sector, or about $870 per capita. The total relocation cost is this figure plus that for loss of income, or about $2900 per capita.

## 12.5 VALUES ASSIGNED TO IMPORTANT PARAMETERS

The values of parameters used in the model for cost calculations are shown in Table VI 12

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TABLE VI 12-1 EPA ESTIMATES OF FOOD, SHELTER, AND TRANSPORTATION COSTS FOR EVACUEES AND EVACUATION PERSONNEL[a]

| Type of Expenditure | Cost per person |
|---|---|
| Evacuee cost: | |
| Food and shelter, daily cost: | |
| Commercial[b] | $11.00 |
| Mass care | 5.00 |
| Transportation: | |
| Private[c] | 1.00 |
| Commercial[d] | 0.55 |
| Evacuator personnel cost: | |
| Compensation | 35.00 |
| Food, shelter, transportation | Same as for evacuees |

(a) From Hans and Sell (1974).

(b) Assumes two or more persons to a room.

(c) Privately owned vehicle, three or four passengers per vehicle, round-trip distance 30 miles, 12¢/mile operating cost.

(d) Assuming 45-50 persons per vehicle, round-trip distance 30 30 miles, 65¢ to 80¢ per vehicle-mile.

TABLE VI 12-2 COST AND EFFECTIVENESS OF FARMLAND DECONTAMINATION

| Condition of Land | Technique | Reduction in Contamination[(a)] R (%) | Decontamination Factor[(b)] DF | Unit Cost[(c)] ($/acre) |
|---|---|---|---|---|
| Tilled soil | Scrape surface and dispose of it | 99 | 100 | 520-810 |
| | Bury surface soil in place by grading | 94 | 17 | 47-120 |
| | Bury surface soil in place by deep plowing | 95.5 | 22 | 75 |
| Grazing land | Bury surface soil in place by deep plowing[(d)] | 95.5 | 22 | 320 |
| Orchards | Scrape surface soil and dispose of it[(e)] | 99 | 100 | 3000-5000 |

(a) Percentage reduction in amount of contaminant per unit of surface area. See section 11.2.2.3, and Appendix K.

(b) DF = 100/(100-R). See Appendix K for discussion.

(c) Estimates based on data presented by the Robert Snow Means Co. (1974), Mohon (1974), and the U.S. Department of Agriculture (1974).

(d) Includes restoring land by reseeding grass.

(e) Includes (1) removing and replacing the plantings and (2) loss of harvest for 5 years.

TABLE VI 12-3 DECONTAMINATION COST FOR A SINGLE-FAMILY DWELLING[a]

| Parameter | Low-Density Dwelling | Medium-Density Dwelling |
|---|---|---|
| Development density (units per acre) | 1 | 5 |
| Average lot size ($ft^2$) | 40,000 | 7260 |
| Street area per residence ($ft^2$) | 3,560 | 1450 |
| Area of driveway ($ft^2$) | 1,000 | 300 |
| Area occupied by structure ($ft^2$) | 2,500 | 2000 |
| Area occupied by lawn ($ft^2$) | 36,500 | 4960 |
| Decontamination factor = 2: | | |
| Cost per dwelling | $4370-5460 | $1020-1170 |
| Cost per capita[b] | $1366-1706 | $ 319-366 |
| Decontamination factor = 20: | | |
| Cost per dwelling | $5950-11,500 | $1800-5220 |
| Cost per capita[b] | $1860- 3,590 | $ 560-1630 |

(a) Rough estimates constructed on the basis of the structure parameters listed in this table.

(b) Assuming 3.2 residents per dwelling.

TABLE VI 12-4 SUMMARY OF CONSTRUCTED COST ESTIMATES FOR DECONTAMINATION OF RESIDENTIAL PROPERTY

| Type of Structure | Development Density | Per Capita Decontamination Cost | |
|---|---|---|---|
| | | DF = 2 | DF = 20 |
| Single-family dwelling unit | 1 per acre | $1370-1710 | $1860-3590 |
| Single-family dwelling unit | 5 per acre | $320-370 | $560-1630 |
| Three-story suburban apartment building (90% occupancy) | Structure occupies 30% of land | $30 | $140-420 |
| Six-story urban apartment building (90% occupancy) | Same | $15 | $70-210 |

TABLE VI 12-5 COMMERCIAL, INDUSTRIAL, AND PUBLIC USE OF URBAN LAND[a]

| | Acres per 100 Persons | | |
|---|---|---|---|
| | Commercial and Industrial Use | Parks | Public Use |
| Central cities | 0.76 | 0.50 | 0.93 |
| Satellite cities | 1.14 | 0.69 | 2.50 |

[a] From Bartholomew (1955).

TABLE VI 12-6 POPULATION-WEIGHTED LAND USE

| Type of Use | Acres per 100 Persons |
|---|---|
| Commercial and Industrial | 0.98 |
| Parks | 0.61 |
| Public | 1.83 |

TABLE VI 12-7 COST ESTIMATES FOR DECONTAMINATION OF COMMERCIAL, INDUSTRIAL, AND PUBLIC PROPERTY

| Type of Structure | Per Capita Decontamination Cost DF = 2 | DF = 20 |
|---|---|---|
| Industrial or commercial building | $21 | $140-490 |
| Parks | $26-$33 | $31-46 |
| Public buildings | $40 | $200-640 |

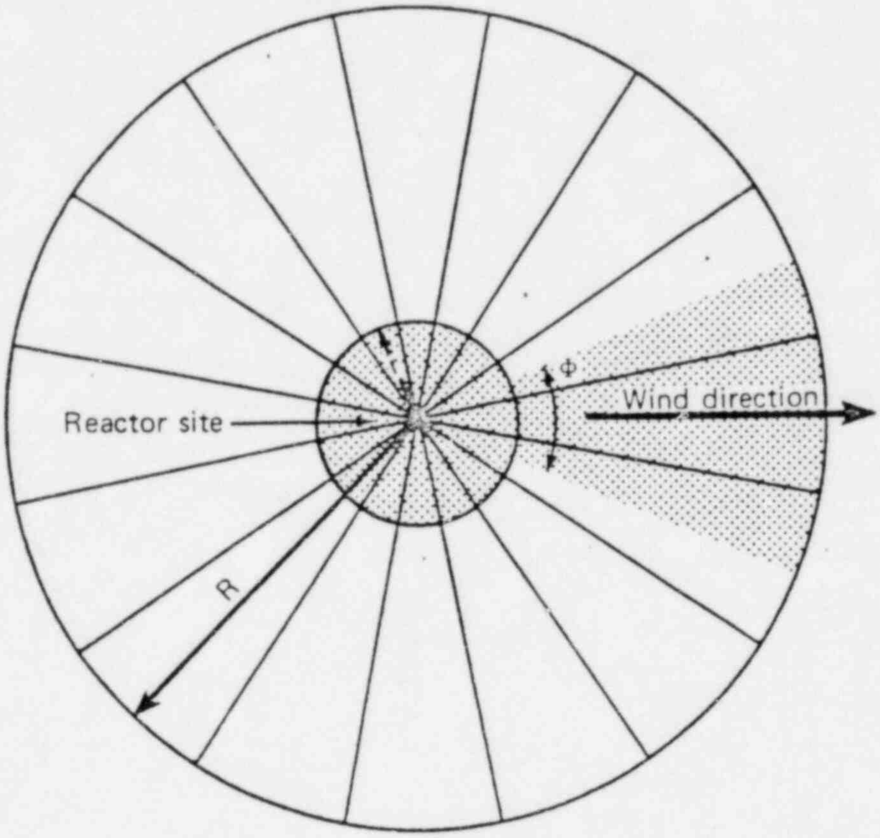
TABLE VI 12-8 EFFECT OF INTERDICTION ON PROPERTY VALUES

| Interdiction Period T (years) | Residential, Business, and Public (a = 0.70) | Farm (a = 0.25) |
|---|---|---|
| None | 100 | 100 |
| 1 | 77 | 85 |
| 5 | 31 | 46 |
| 10 | 12 | 24 |
| 20 | 3 | 7 |

TABLE VI 12-9 INPUT PARAMETERS FOR THE MODEL

| Parameter | Value | Remarks |
|---|---|---|
| Distance of evacuation in the downwind direction (m) | $3.2 \times 10^4$ | R = 25 miles in Figure VI 12-1 |
| Distance of evacuation in the upwind direction (m) | $8.0 \times 10^3$ | $\gamma$ = 5 miles in Figure VI 12-1 |
| Angle of evacuated area (degrees) | 45 | $\phi$ in Figure VI 12-1 |
| Duration of release (hours) | 3 | When the duration of release is shorter than 3 hours, the evacuated area would have the shape shown in Figure VI 12-1; when it is longer, the area within a 25-mile radius will be evacuated |
| Cost of evacuation per evacuee | 95 | \$13.5/day x 7 days |
| Loss of milk and crops | See Table VI 10-4 | |
| Loss of property: | | |
| Depreciation rate of improvements ($yr^{-1}$) | 0.20 | |
| Value of farm property | See Table VI 10-4 | |
| Value of developed property[(a)] (per capita) | \$17,000 | |
| Relocation cost per capita | \$2,900 | |
| Decontamination: | | |
| Decontamination cost of farmland (\$/acre) | \$230 | |
| Decontamination cost of developed land for DF = 2 | \$700 | |
| Decontamination cost of developed land for DF = 20 | \$2,000 | |

(a) Data from National Bureau of Economic Research (1971).




R = 25 miles

r = 5 miles

Φ = 45 degrees

FIGURE VI 12-1 Segmentation of area surrounding reactor.

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

| | | |
|---|---|---|
| In the Matter of | ) | |
| | ) | |
| THE CLEVELAND ELECTRIC ILLUMINATING COMPANY, ET AL. | ) | Docket Nos. 50-440 50-441 |
| | ) | |
| (Perry Nuclear Power Plant, Units 1 and 2) | ) | |

## CERTIFICATE OF SERVICE

This is to certify that copies of the foregoing "Applicants' Answer To Ohio Citizens For Responsible Energy Motion For Leave To File Its Contention 20," were served by deposit in the U.S. Mail, First Class, postage prepaid, this 31st day of August, 1982, to all those on the attached Service List.

Robert L. Willmore

Dated: August 31, 1982

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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