NUREG/CP-0026
MTR-82W26

Proceedings of the

Workshop on Psychological Stress Associated With the Proposed Restart of Three Mile Island, Unit 1

Held at
McLean, Virginia
February 4-5, 1982

P. Walker, W. E. Fraize, J. J. Gordon, R. C. Johnson

Sponsored by
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission

Proceedings prepared by
The MITRE Corporation

Available from

GPO Sales Program
Division of Technical Information and Document Control
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Printed copy price: $6.00

and

National Technical Information Service
Springfield, VA 22161

NUREG/CP-0026
MTR-82W26

Proceedings of the

Workshop on Psychological Stress Associated With the Proposed Restart of Three Mile Island, Unit 1

Held at McLean, Virginia
February 4-5, 1982

Manuscript Completed: March 1982
Date Published: April 1982

P. Walker, W. E. Fraize, J. J. Gordon, R. C. Johnson

Sponsored by
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Proceedings prepared by
Energy and Resources Division
The MITRE Corporation
McLean, VA 22102

ABSTRACT

On 4 and 5 February 1982, eleven experts in the field of psychological stress and related fields met for a two-day Workshop at The MITRE Corporation, McLean, Virginia. The general purpose of the Workshop, sponsored by the Nuclear Regulatory Commission, was to assess the state-of-knowledge relevant to assessing psychological stress which may be associated with the restart of the nuclear power reactor Unit 1 at the Three Mile Island site of the Metropolitan Edison Company (TMI-1). Of particular interest was the extent to which existing concepts and studies might be used to extrapolate or infer the range of stress responses likely to result from the proposed restart of TMI-1. This report summarizes the discussions of the Workshop participants.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Concluded)

ACKNOWLEDGMENT

The authors of this summary report gratefully acknowledge the spirit with which the expert participants entered into discussions, the self discipline demonstrated by the expert observers in delivering their messages within the specified time constraints, and the restraint exhibited by the other Workshop observers in complying with the Workshop ground rules on participation. We also particularly would like to thank Donald Cleary, Patricia Rathbun and William Regan of the NRC for their guidance and involvement in designing the Workshop; Diane Pask for her attention to the logistic details; and Jan Kindrick, Diane Pask and Vicki Ziegenhagen for their considerable secretarial effort in producing this summary report in a timely manner.

SUMMARY REPORT
WORKSHOP ON PSYCHOLOGICAL STRESS
ASSOCIATED WITH THE PROPOSED RESTART OF
THREE MILE ISLAND, UNIT I

EXECUTIVE SUMMARY

Following the accident at the Three Mile Island Unit 2 (TMI-2) nuclear power plant, the decision to restart the undamaged TMI-1 unit, located on the same site, was delayed pending Nuclear Regulatory Commission (NRC) review. During the TMI-1 restart hearing process, the contention was raised by People Against Nuclear Energy (PANE) that psychological stress might occur within the TMI community as a result of the TMI-1 restart, and this possibility should be considered in NRC's decision. A U.S. Court of Appeals decision on 7 January 1982 supported PANE's contention.

In response to the court decision, the NRC has begun the process of preparing an environmental assessment of the effects of a proposed TMI-1 restart on the psychological health of the residents and on the well-being of the communities in the TMI neighborhood. An early step in preparing such an environmental assessment is to ascertain the state-of-knowledge of psychological stress to determine the extent to which psychological stress associated with a restart of TMI-1 can be predicted.

Accordingly, the MITRE Corporation, at the request of the NRC, convened a two-day workshop on the 4th and 5th of February 1982, consisting of eleven nationally recognized experts in the field of psychological stress. These Workshop participants shared professional judgments, hypotheses, research methods and study results to address the following questions, which constitute the essence of the Workshop objectives:

- What can we infer or extrapolate from existing concepts and studies concerning the psychological responses that will be exhibited among the TMI population as a result of a TMI-1 restart?
- What is the scientific basis for predicting the types and ranges of these psychological stress responses?
- What additional near term efforts are required to increase the confidence in these predictions?

Workshop Response to Objectives

The discussion below summarizes, in order, the response to each of the three Workshop objectives. This information is drawn

primarily from Sections 2.5, 2.6, and 2.7 of the report and is supplemented by information drawn from the other summaries contained in Section 2.0.

Inference and Extrapolation to the Potential Psychological Stress of a TMI-1 Restart

Many participants stated that generalized predictions of stress responses associated with a restart of TMI-1 can be made; however, the limitations of social science theory and methodology, as well as inadequate data, are likely to yield predictions in which they would not place a high degree of confidence. Responses to the TMI-2 accident and the venting of krypton gas are felt to bound the upper end of potential stress response. Stress responses to a TMI-1 restart are expected to be lower in magnitude than those associated with the accident, possibly being more comparable to those associated with the venting. (It was noted that responses to the krypton venting were mediated by agreement among officials, the media and authoritative scientific sources that the venting was necessary and would not be harmful to the TMI population.)

Specific items that are amenable to prediction, in the TMI context, with greater confidence are:

- the incidence of the acute* stress response, particularly that which is short lived;
- the qualitative severity of the acute stress response;
- the character and effects over time of much of the acute stress response; and
- subgroups at high risk for acute stress.

Relevant items about which predictions cannot be made with much certainty are:

- the incidence, duration, and effects of long-term, low-level stress;
- the emergence and incidence of a chronic disabled group;
- the character and effects over time of the stress response in any chronic disabled group; and
- subgroups at high risk for chronic disability.

*Acute, in the context of the Workshop discussions, referred to rapidity of onset of symptoms rather than magnitude of the response.

The Scientific Basis for Predicting Psychological Stress

Existing theory regarding stress and stress responses, as well as data gathered following the TMI-2 accident and in conjunction with the krypton venting constitute the primary scientific basis for prediction of the types and ranges of psychological stress responses associated with a restart of TMI-1. Theory indicates that responses to a threat may have a common core of biological and psychological reactions which may be qualitatively the same regardless of the source of the threat. Accordingly, responses to a TMI-1 restart are not expected to be qualitatively different from responses to other situations involving fear. The results of studies of the TMI population tend to support this premise.

The basis for quantification of the stress response, particularly with respect to severity and duration, is more complicated. Although a body of literature exists on responses to natural disasters and other transient stresses, the issue of its applicability to a TMI-1 restart remains unresolved. Some participants argued in favor of extrapolating from this literature, contending that the qualitative similarities between the TMI-2 accident and natural disasters make such extrapolation appropriate. Others argued, in contrast, that the TMI-2 accident was too minor an event to define as a disaster; hence, extrapolation from the disaster literature will overestimate the stress of a TMI-1 restart. Others agreed that extrapolation from the disaster literature is inappropriate, but based their position, instead, on the argument that having been subject to the TMI-2 accident and sensitized by the experience, the TMI population is unique.

Compensating for the ambiguity regarding use of the disaster and transient stress literature are the TMI data. These data provide extensive, if incomplete, knowledge of the incidence, severity, and duration of stress responses. They do not, however, include any pre-accident baseline measurements. The data collected to study the psychological effects of krypton venting offer some insight into the response of a sensitized population to a new event that is related to a prior stressful event. Inasmuch as the effects of stress may be cumulative, the krypton venting, however, will have additionally transformed the TMI population, perhaps affecting its response to a restart of Unit 1.

TMI data also permit identification of some subgroups at high risk for acute stress. Further analysis of TMI data, supplemented by relevant theory, may yield the identity of additional high risk groups. In the absence of additional research on the TMI population and further development of identification techniques, some, but not necessarily all, high risk groups can be identified.

An unanticipated finding in several of the TMI studies was the longevity of a low level stress response in part of the population after both the TMI-2 accident and the krypton venting. There is a dearth of theory and data on the incidence and effects of long-term, low level stress, thereby leaving the scientific basis for assessment of this phenomenon incomplete.

A group which it may be important to understand but also difficult to assess, given the limitations of existing theory and data, is the chronic disabled. This group is expected by some of the participants to emerge over the long term, after most people with acute stress responses to TMI have resolved their problems. Given the present knowledge base, a priori identification of those at high risk for being among the chronic disabled will be difficult and prediction of any incidence of chronic disabled onerous. The fairly limited time frame of existing studies, the type of sampling procedures employed and an insufficient understanding of this response preclude identification and analysis from existing TMI data of a chronic disabled group. A particular problem with regard to any chronic disabled is establishing whether a link actually exists between their later disability and the TMI-2 accident or any TMI-1 restart. Unlike prediction of acute stress, therefore, the disaster and transient stress literature was regarded by some participants to be the principal source of information for assessing any chronic disabled. The literature on veterans exposed to Agent Orange during the Viet Nam War and to chlorine gas during World War I was cited as a potentially useful source of information.

Participants felt strongly that predictions be accompanied by the researchers' degree of confidence in the results. The possibility was raised that the uncertainty of the predictions could be so high that they would not be willing to make them at all. Thus, data and methodological limitations that tend to reduce participants' confidence in predictions, and caveats that should be observed if predictive efforts are undertaken were discussed. Limitations and caveats include:

- Dissimilarities between a TMI-1 restart and prior TMI-2 events and natural disasters will make predictions uncertain.

- The data base on the TMI population is limited. TMI-2 studies are descriptive, not designed for prediction.

- Expressed attitudes toward restart will be an important source of information from which extrapolations would have to be made; yet the relationship between expressed attitudes and future stress is problematic.

- An insufficient understanding of causal variables impedes interpretation of statistical data on TMI-2.

- Characteristics that describe the high risk subgroups are not well understood, making a priori identification of these individuals difficult.

- Existing theory and data preclude the satisfactory assessment of any chronic disabled group and of the long term, low level stress response.

Near-Term Efforts to Increase Confidence in Predictions

The expert participants recommended additional data gathering and analysis efforts in two areas: data specific to the TMI population and non-TMI data. The former was generally felt to be the more useful. Three recommendations regarding the TMI-specific data emerged:

- Reanalyze existing TMI data with the objectives of identifying high risk groups, systematically correlating interstudy consistencies, and discerning additional associations that may help in predicting stress responses.

- Analyze existing raw TMI data which focus on mothers and TMI workers; data concerning attitudes of these subgroups towards a TMI-1 restart are especially pertinent.

- Gather additional data among the TMI population for the purposes of establishing improved baselines (for evaluating stress responses to a TMI-1 restart and developing interventions to ameliorate the stress), identifying and analyzing additional high risk groups, and assessing possible psychological impacts of a decision not to restart TMI-1.

The first recommendation was developed under the assumption of a one-month time constraint, the latter two under the assumption of a six-month constraint.

In the area of non-TMI data, the Workshop participants suggested a focused review of literature concerning general crises, natural disasters and events leading to chronic psychological disability (e.g., exposure to Agent Orange). The purposes for examining the non-TMI data would include: defining bounds on the fraction of the population likely to be affected at various stress levels, characterizing chronic disabled groups and estimating rates of chronic disability.

Participants identified guidelines to be employed should additional efforts be considered:

- Any additional research should be designed to provide information qualitatively different from that already available.

- Accepted theories of stress should be used to identify major causal variables and to predict types of responses; existing data should then be analyzed with reference to theory.

- A multiple method approach should be used. People evidence stress in a variety of ways and no single method can capture all manifestations of stress. Further, the techniques themselves are imperfect.

- No new studies should be initiated unless it is determined that the existing data base is inadequate. Also considered should be the fact that postponement of a TMI-1 restart may delay conflict resolution.

Among the benefits to be expected from additional short term (i.e., one to six months) data gathering and analysis efforts, the participants highlighted: increased qualitative and potential statistical confidence in predicting stress response, more certain identification of high risk groups, and more effective targeting and development of treatment programs and intervention techniques.

Additional Workshop Discussions

Stress is one of a number of psychological effects of nuclear power. The concept of nuclear power held by the public affects the psychological impacts of this technology. Studies referred to by one participant indicate that a common belief is that nuclear power is a risk or threat second in magnitude only to nuclear war. Except in the early perceptual or cognitive phase, stress due to nuclear power leads to responses qualitatively similar to responses due to other events involving fear. It was noted that the media has a major affect on the publics' understanding of nuclear power, since for most individuals it is their only contact, albeit an indirect one, with the technology.

Participants presented the results of several studies conducted on the TMI population to assess the psychological effects of the TMI-2 accident and the krypton venting. Overall, stress responses appeared to be fairly mild. The studies, as analyzed to date, have

shown that there was an increased incidence of somatization* observed in the general TMI population immediately after the TMI-2 accident. These symptoms were generally found more frequently and at higher levels among individuals closer to TMI. With the passage of time since the accident, symptoms of stress generally decreased in frequency and extent. The studies have helped to identify certain high risk subgroups. Perceptions of TMI as a threat and distrust of public officials persist.

Analogies from natural disasters and other transient stress events to the TMI-2 accident and to a restart of TMI-1 were sought, but none were agreed upon by all the participants. The intangible nature of the conseqences to the community resulting from the accident is a major characteristic differentiating the accident from a natural disaster. The lack of visible damage prevented many residents from clearly defining what had occurred and from taking corrective measures. The fact that a possible restart of TMI-1 involves anticipatory stress made analogies to natural disasters additionally difficult.

Participants elaborated on the acute and chronic stress responses. Acute responses generally are relatively short lived and are considered normal reactions to stressful events. Some participants were surprised that in the TMI community low level stress appears to have been maintained over an unusually long period of time. Others felt that these low levels may reflect normal conditions among the TMI population. Illness due to chronic stress most often occurs in people who have concurrent life problems and who have a past history of personal difficulties which predisposes them to chronic disability.

Ameliorative actions that might lessen the psychological stress impact of a TMI-1 restart should focus on education, information access and counseling. Actions should be implemented only after the public is assured of the safety of TMI-1 and the case for a restart of this unit convincingly presented. The media, particularly interactive television, could contribute to keeping the public well informed, thereby potentially lessening the psychological impacts that might be associated with TMI-1 restart.

---

*The expression of mental experiences or states in the form of physical symptoms.

ABBREVIATED SUMMARY
WORKSHOP ON PSYCHOLOGICAL STRESS
ASSOCIATED WITH THE PROPOSED RESTART OF
THREE MILE ISLAND, UNIT 1

Psychological Effects of Nuclear Power

- Stress is only one of many potential psychological effects of nuclear power, and is not necessarily harmful.

- Stress can be aggravated by stress responses.

- Psychological stress of nuclear power is strongly linked to the public's concept of the technology as a risk or threat.

- Psychological stress associated with nuclear power may be unique only in the early cognitive phases; longer term effects are similar to those for other events involving fear.

- Nuclear power is believed risky because:

  - Calamitous accidents are possible.
  - The technology is largely unknown and involuntarily imposed.
  - The expert community disagrees on risk and safety issues.
  - Radiation is unseen and its damage may be only fully apparent in the future.

- The believed risk of nuclear power may be affected by:

  - media coverage,
  - individual knowledge of the technology,
  - individual political and ideological positions, and
  - individual emotional health.

Studies of Psychological Stress in the Vicinity of TMI

- There was an increased incidence of somatization, found more frequently and at greater levels among individuals living closer to TMI, observed in the general TMI population immediately after the TMI-2 accident.

- With the passage of time since the accident, symptomatology generally decreased in frequency and extent, although in one study symptom reporting was still elevated above expected levels as much as seventeen months after the accident.

- As long as 18 months post-accident, people living near TMI were attributing reported behavioral and somatic symptoms to the accident, although their rate of symptom reporting was essentially the same as a control group that did not attribute symptoms to TMI.

- The TMI population responded to another nuclear-related event (i.e., venting of krypton gas) with anticipatory stress and with low level but long lived stress after the venting ceased.

- Perceptions of TMI as a threat and distrust of public officials persist.

Concepts, Causes and Consequences of Stress Which May Be Applicable to the TMI Restart

- The TMI-2 accident, unlike a natural disaster, was characterized by uncertainty of the extent of the damage and lack of resolution. The resulting stress was compounded by the fear of nuclear accidents and the long-term but not immediately apparent effects of radiation damage.

- The best analogies to TMI-2 in the literature may be events like chlorine exposure in World War I or agent orange exposure in Vietnam. These situations, like radiation events, are characterized by uncertainty over the extent of impacts or damage that may not be known for years.

- Acute stress responses have been observed at TMI. These normal responses to a stressful situation were initially relatively mild and have since declined to low but slightly elevated levels. The implications of these low, long-term levels of stress are not known. Blaming and coping by attacking the external problem may perpetuate lack of resolution.

- A chronic disabled group may emerge over time. This group, probably different in membership from the groups originally manifesting stress, may be characterized by many life problems and is likely to attribute disability to the TMI-2 accident.

Evaluation of Methods Used in Identification and Measurement of Stress and Stress Reponses

- Multiple measures and methods are needed. Each method has its own shortcomings; but, when used together, methods may provide a convergence or consensus in the major findings.

- Traditional measures of stress impacts may need to be broadened to include chronic degenerative states and some appropriate quality of life indicators.

- Identification of high risk groups has been done on an a priori basis and may not be inclusive. The identification of high risk individuals is particularly difficult.

Ability to Extrapolate from Existing Studies to TMI-1 Restart

- Generalized predictions of the psychological impacts of a TMI-1 restart can be made, but researchers' confidence in the predictions may be low.

- Data specific to TMI will be more important for extrapolation than will be the disaster literature.

- Responses to the TMI-2 accident and krypton venting are believed to bound the upper range of responses to a restart of TMI-1.

- The incidence of acute stress can be measured and predicted with the greatest confidence, many subgroups vulnerable to acute stress can be identified, and the temporal pattern of that stress can be predicted.

- Prediction of chronic stress and identification of those at high risk for this problem is highly uncertain.

- Caveats that should be observed if predictive efforts are undertaken include:

  - Dissimilarities between a TMI-1 restart on the one hand and prior TMI-2 events and natural disasters on the other will make predictions uncertain.
  - The data base on the TMI population is limited, especially with respect to attitudes toward TMI-1 restart.
  - The relationship between expressed attitudes toward restart and future stress responses is problematic.
  - Social science knowledge of the effects of long-term, low level acute stress is limited.
  - An insufficient understanding of causal variables impedes interpretation of statistical data.

- The following assumptions will facilitate extrapolations:

  - The stress response to a TMI-1 restart will be normally distributed.
  - The population's coping ability has been affected by the accident.
  - Specific subgroups will be more vulnerable to stress.
  - A chronic disabled group may emerge over the longer term.

Technical Considerations for Predicting Psychological Stress Associated with a Restart of TMI-1

- Existing data specific to TMI-2, including data on the venting of krypton gas, offer the best basis for predicting the psychological effects of a TMI-1 restart.

- Analysis of TMI data should focus on:

  - attitudes toward a TMI-1 restart,
  - identification of subgroups highly stressed from the TMI-2 accident,
  - possible correlation between opposition to nuclear power and TMI-1 restart and stress, and
  - changes in stress over time.

- The disaster and transient stress literature, especially studies of exposure to Agent Orange and chlorine gas, appears to be the best source of information for assessing the nature and incidence of any chronic disabled.

- The stress of not restarting TMI-1 should be considered.

- It is important that predictions be made with adequate confidence. The following factors tend to reduce confidence in predictions:

  - TMI-2 studies are descriptive, not designed for predictions.
  - Predictions require assumptions that events and populations associated with the TMI-1 restart are similar to those associated with the TMI-2 accident and krypton venting.
  - Techniques for identifying high risk subgroups may be inadequate.
  - Existing theory and data preclude satisfactory assessment of any chronic disabled group.

Additional Near Term Efforts Needed to Fill Gaps in Existing Concepts and Studies

- Collectively reanalyze existing TMI data.

- Analyze recently collected TMI data that have not yet been evaluated.

- Conduct a focused review of the existing non-TMI literature concerning general crises, natural disasters and chronic psychological disability.

Ameliorative Actions

- Ameliorative actions could minimize the potential psychological stress response to a TMI-1 restart.

- Ameliorative actions should emphasize education, information access and open confrontation with the source(s) of fear.

- Preconditions for implementing ameliorative actions include convincing the public of:

  - TMI-1 safety,
  - need for a TMI-restart, and
  - credibility of officials.

- Ameliorative actions should:

  - avoid large forums;
  - rely on a single authoritative information source (as in a continuous, interactive TV broadcast);
  - involve credible public authorities in addition to the NRC;
  - focus on vulnerable, at-risk groups; and
  - be scheduled and sustained for maximum benefit.

1.0 BACKGROUND

This section provides a brief overview of the salient events leading up to the decision of the Nuclear Regulatory Commission (NRC) to sponsor the Workshop on Psychological Stress. It also summarizes the chosen objectives for the Workshop, identifies the Workshop attendees and describes their roles and responsibilities. As a last item, the organization of the remainder of this summary report is explained.

1.1 Sequence of Events

On 28 March 1979 an accident damaged the Three Mile Island (TMI) nuclear power reactor Unit 2, known as TMI-2, at the electric generating station of the Metropolitan Edison Company near Harrisburg, Pennsylvania. Attendant to the accident was the need to inform the local population of: the potentially dangerous situation at the site, the possibility of release of radioactive material and the precautionary voluntary evacuation of people within a five mile radius of the plant.

Coincidentally, at the time of the accident, the other nearly identical nuclear power reactor, TMI-1, on the same Three Mile Island site was shut down for scheduled maintenance and refueling. The Nuclear Regulatory Commission ordered the TMI-1 reactor, although undamaged by the accident, to remain shut down pending further NRC action.

The NRC subsequently announced the formation of a Licensing Board charged with conducting public hearings and defining issues appropriate for NRC consideration prior to authorization of any TMI-1 restart. The issue of psychological stress among the people living in the vicinity of the plant that might result from a TMI-1 restart was raised. Specifically, People Against Nuclear Energy (PANE) filed two contentions* related to psychological stress for the Board's consideration:

1) Renewed operation of Three Mile Island, Unit 1 (TMI-1) would cause severe psychological distress to PANE's members and other persons living in the vicinity of the reactor. The accident at Unit 2 has already impaired the health and sense of well being of these individuals, as evidenced by their feelings of increased anxiety, tension and fear, a sense of helplessness and such physical disorders as skin rashes, aggravated ulcers, and skeletal and muscular problems. Such manifestations of psychological distress have been seen in the aftermath of other disasters. The possibility that TMI Unit 1 will reopen severely aggravates these problems. As long as the possibility exists, PANE's members and other persons living in the communities around the plant will be unable to resolve and recover from the trauma which they have suffered. Operation of Unit 1 would be a constant reminder of the terror which they felt during the accident, and of the possibility that it will happen again. The distress caused by this ever present spectre of disaster makes it impossible for the NRC to operate TMI-1 without endangering the public health and safety.

2) Renewed operation of TMI would cause severe harm to the stability, cohesiveness and well-being of the communities in the vicinity of the reactor. Community institutions have already been weakened as a result of a loss of citizen confidence in the ability of these institutions to function

*These contentions are reproduced from the brief filed by William S. Jordan, III, Counsel for People Against Nuclear Energy, dated 3 June 1981 and filed under Docket No. 81-1131.

> properly and in a helpful manner during a crisis. The potential for a reoccurrence (sic) of the accident will further stress the community infrastructure, causing increased loss of confidence and a breakdown of the social and political order. Sociologists such as Kai Erikson have documented similar phenomena in other communities following disasters.
>
> The perception, created by the accident, that the communities near Three Mile Island are undesirable locations for business and industry, or for the establishment of law or medical practice, or homes compounds the damage to the viability of the communities. Community vitality depends upon the ability to attract and keep persons, such as teachers, doctors, lawyers, and businesses critical to economic and social health. The potential for another accident, should TMI-1 be allowed to operate, would compound and make permanent the damage, trapping the residents in disintegrating and dying communities and discouraging the influx of essential growth.

The Licensing Board reviewed the question of the admissibility of psychological stress contentions in the TMI-1 restart proceedings and concluded on 22 February 1980 that while not required to do so, the NRC "may and should consider psychological stress and community fears under NEPA* for the purpose of mitigating the effects of its TMI-1 licensing activities." The Commission, on a 2-to-2 vote, was divided on whether psychological stress issues should be considered. The tie vote, however, amounted to an effective denial of PANE's two contentions.

PANE appealed the NRC decision to the U.S. Court of Appeals for the District of Columbia Circuit. On 7 January 1982 the Appeals Court decided in PANE's favor and directed the NRC to prepare an

---

*National Environmental Policy Act.

"environmental impact assessment regarding the effects of the proposed restart of the nuclear facility at Three Mile Island Unit One (TMI-1) on the psychological health of the neighboring residents and on the well-being of the surrounding communities." The Court's decision noted that such an assessment had never previously been required or considered under the National Environmental Policy Act. Thus, there are no precedents for the NRC to follow in developing such an assessment. The judgment as rendered on 7 January 1982 may be found in Appendix A.

1.2 Workshop Objectives

While the NRC is considering what formal action to take, it has directed its staff to prepare an environmental assessment of the effects of the proposed restart of TMI-1 on both the psychological health of neighboring residents and on the well being of the communities surrounding TMI. While the NRC staff has familiarity with psychological stress related to natural disasters and with the TMI-2 accident, it felt the need for expert guidance on the ability to predict psychological stress responses for a future event, such as a TMI-1 restart. Hence, this Workshop was convened with the express purpose of obtaining expert opinion both on the extent to which existing concepts and data would permit reliable estimation of the psychological stress responses that may be associated with the proposed TMI-1 restart and on the possible need for additional studies before such an assessment could be made.

Specifically, the Workshop was charged with obtaining answers from the expert community to the following questions:

- What can we infer or extrapolate, from existing concepts and retrospective or longitudinal studies, concerning the range of stress responses that will be exhibited among the population in the vicinity of TMI to a restart of TMI-1?
- What is the scientific basis for prediction of the types and ranges of these responses to the psychological stress associated with a restart of TMI-1?
- What, if any, gaps must be filled in order to increase your confidence, as an expert, in these predictions? How might these be filled?

1.3 Workshop Organization

The two day Workshop on the 4th and 5th of February 1982 at The MITRE Corporation in McLean, Virginia, consisted primarily of a gathering of eleven of the nation's recognized active researchers and clinicians in the field of psychological stress associated with both natural and technology-related disasters (see Appendix B for a list of the expert participants). The eleven experts were guided in their efforts to address the Workshop objectives by an experienced but neutral facilitator for such group activities, Dr. Arthur Freedman of the National Training Laboratories. Dr. Freedman's role was to keep the discussion focused on the topics outlined in the agenda (see Appendix C), with the intent that thorough discussion of these issues would provide answers to the three questions framed as the Workshop objectives.

In addition to the experts, two other groups were present:

- expert observers, who were identified prior to the meeting as likely to have substantive contributions to make to the Workshop discussions and who were invited to address the expert panel at several specific points in the agenda for brief time intervals (see Appendix B for a list of the expert observers) and,

- non-participating observers from the NRC, MITRE, PANE and the affected utility among others (see Appendix B for a list of the attendees on each day).

The meeting was conducted as a workshop, not a hearing or an advisory board. The expert participants were encouraged to share professional judgments and hypotheses as well as research conclusions. The group was not instructed to strive for consensus or to avoid disagreement. It was not the explicit purpose of the Workshop to provide specific recommendations to the NRC. The Workshop discussions were recorded by a professional court reporter. This report is a summary of those discussions as they relate to the Workshop objectives.

1.4 Report Organization

Sections 2.1 to 2.7 of this document follow the general outline of the agenda and summarize, within that framework, the major items of discussion, including different perspectives that were aired at the Workshop. Although Section 2.8, Ameliorative Actions, was not a major topic on the Workshop agenda, it was an issue of some interest during many of the Workshop discussions. It is, therefore, included with the summaries of the other Workshop discussions. Every attempt has been made to keep this summary report faithful to the transcript.

The summary report has been reviewed by each of the expert participants.

In addition to this summary of the Workshop discussions, each expert was given an opportunity to respond to the Workshop discussions by means of a post-Workshop opinion paper. The papers of those who chose to submit them are presented in Section 3.0.

In Appendix A the U.S. Court of Appeals Judgment issued on 7 January 1982 is presented. Expert participants, expert observers and attendees lists are included in Appendix B. The Workshop agenda is presented in Appendix C. Citations are provided in Appendix D for bibliographic material mentioned during Workshop discussions.

2.0 SUMMARIES OF WORKSHOP DISCUSSIONS

As indicated previously, this section is organized according to the Workshop agenda (see Appendix C) with the exception of the last subsection, 2.8, Ameliorative Actions. Section 2.8 is included here because it was the subject of considerable discussion at several points during the Workshop.

The introduction to each of the eight subsections (i.e., 2.1 through 2.8) indicates the general purpose of the session and the major topics discussed during the session. Thereafter, the subsections relate directly to Workshop discussions and present only material considered during the Workshop, with the exception of the asterisk-indicated notes in section 2.2. Although the material in the notes was a topic of conversation during the session, the citations are not contained in the transcript and were not given during the session. Each of the researchers noted provided the citations.

In the following sections a variety of terms are considered equivalent to or inclusive of the expert participant(s), e.g., participant(s), panel, Workshop member(s). Unanimity of agreement among the expert participants is not implicit in the use of any one of these terms. When there was apparent agreement (i.e., no dissent expressed) among the expert participants concerning an issue presented in this summary report, it is so noted.

2.1 Psychological Effects of Nuclear Power

The Workshop opened on the topic of psychological effects of nuclear power in general, before getting into the more specific TMI-related objectives of the Workshop. This ordering was chosen to allow the assembled experts to begin the process of defining key terms and concepts. The discussion during this session included the nature of the psychological effects associated with nuclear power, the manner in which nuclear power is perceived by the public, the identification of generic and unique aspects of nuclear-related stress, and the public's understanding of the risk of nuclear power.

2.1.1 Nature of the Psychological Effects

The participants suggested that stress is only one of many potential psychological effects of nuclear power and that psychological stress can have several sources. While a major cause of stress may be a fear of nuclear power, stress may also have secondary causes such as the various coping actions that residents in the vicinity of a nuclear plant may elect to take. Coping style and its resulting actions, such as moving one's residence or engaging in political action, may increase stress levels.

The manner in which public officials and technical experts characterize nuclear power can also affect psychological stress among the general public. It was suggested that stress can be

increased by the very awareness of official concern over stress response levels related to nuclear power. Decisions to delay or interrupt the operation of nuclear power plants for safety-related reasons may support the public's view that nuclear power is risky.

In assessing the effects of nuclear power on the psychological health of the community, it was felt important to recognize that stress and its responses are not necessarily harmful. While some in a nuclear plant community may be harmfully stressed, others may not be stressed at all or may use the stress as a catalyst for establishing a stress-relieving coping response. For example, political efforts may lead to community cohesiveness, promoting feelings of satisfaction among the community members. This is not to say that psychological stress as it may be associated with nuclear power was not felt to be of major concern, but, rather that it is a complicated, multi-variable problem not amenable to simple characterization or solution.

2.1.2 Characterization of Nuclear Power by the Public

The expert participants identified many of the ways in which nuclear power is characterized or viewed by the public. Understanding the public's views of nuclear power was felt by some to be an essential first step in assessing psychological stress and possibilities for its mitigation.

Many of those who react negatively to nuclear power perceive it as a risk or a threat. The participants noted that this sense of risk results from many causes, some of the more important ones being:

- There is the possibility, however remote, for unpredictable, catastrophic accidents at a nuclear power facility; this may impart a certain dread quality to nuclear power, making it generally believed by the public to be riskier than anything but a nuclear war.

- Nuclear power involves the use of very sophisticated technology which is unknown and largely incomprehensible to the general public; lack of knowledge of nuclear power can translate to fears of its potential consequences.

- The public feels that nuclear power is involuntarily imposed upon it by forces and institutions outside its control.

- There is no way for an individual to perceive the extent, if any, of personal radiation exposure; and, once exposed, there is no way to escape its effects or to be immediately certain of the extent of those effects.

- The expert technical community, when addressing such issues as nuclear plant safety and the dangers of radiation exposure, frequently displays disagreement among its members, a fact which reinforces public confusion and fear of nuclear power.

2.1.3 Generic and Unique Aspects of Stress Associated with Nuclear Power

The participants identified many ways in which nuclear-power-related stress responses are analogous to the responses to other technology-related or natural events. At the same time, the unique aspects of nuclear power as a cause of stress were discussed. While they generally agreed on the ways in which stress from nuclear power was either similar to or different from other major sources of stress (such as living in an earthquake-prone region), there was disagreement over the relative importance of the stress characteristics. This led some to assert that the unique aspects of nuclear-power-related stress were the more important, with others

feeling that such stress could be well understood by analogy with other major stress-causing events.

The expert participants discussed at least three ways in which stress and stress responses associated with nuclear power may be unique:

- The early perceptive or cognitive phases of the threat associated with nuclear energy, including the manner in which the public is made aware of how the technology operates and is told what to anticipate, can make the stress response unique. The early perceptual or cognitive phase defines the initial stress response only; thereafter, stress responses may not be unique.

- The potential for nuclear accidents is more likely to cause anticipatory stress, a topic on which there has been little research to date.

- Whereas the types of stress response may be similar to those of non-nuclear events, nuclear-related stress may be unique in terms of the levels of stimulus and stress response.

Among the ways in which nuclear-related stress may be generically similar to other external sources of stress, the expert participants identified the following:

- Fear of nuclear power is an important stress agent; the resulting stress responses are likely to be similar to those for other situations which involve fear.

- Stress resulting from nuclear power is related, at least in part, to the mutually reinforcing effects of a sense of fear and helplessness associated with 20th century technology in general.

- The effects of continuing stress on a specific population are cumulative over time.

While many aspects of initial stress responses to a nuclear event may be unique, the similarity to responses to other events is

likely to increase over time. This may suggest that after the initial response, effects of psychological stress can be understood by reference to experience with other fear-inducing events.

2.1.4 Perceived Risk of Nuclear Power

Psychological stress associated with nuclear power is closely tied to the believed risk of the technology. At the same time, the concept of risk does not necessarily lead to stress in the individual. The Workshop devoted considerable discussion time to understanding the nature of this believed risk.

The public's feelings concerning the risk of nuclear power is affected by the way its benefits are assessed. One participant observed that other risk-laden experiences (such as air travel) are believed to have acceptable levels of risk because the public is fully aware and appreciative of the benefits. Nuclear power may be generally believed to have very little benefit (since there are alternative sources of electricity), a feeling that affects attitudes toward accepting the risk.

The role of the media in the public's concept of nuclear risk was discussed throughout the Workshop. The participants noted the very significant impact the media, especially television, can have both in aggravating and, as discussed in Section 2.8, possibly ameliorating public fear of nuclear power. For most people, the media is their only contact with nuclear power; therefore, the experience is only through indirect exposure. In contrast, public

fear of aviation, for instance, is less dependent on the media since it is tempered for most people by their personal direct experiences with flying. The media's influence is also strong because many people feel the media is telling them what they ought to know.

The media can aggravate public fear through what one participant termed the "over-reporting of minor events." Stress symptom data taken during and after the krypton venting at TMI have suggested that attribution of symptoms to TMI may be related to the frequency with which the event was referenced in the media. Some panelists felt that initial stress responses may be strongly influenced by press coverage; long term disability is not so closely linked to the media.

The panelists distinguished between objective and subjective belief of risk. Although some members felt that a distinction between objective (rational) and subjective (irrational) fears was not very helpful, some felt that both types of fear had to be dealt with. Irrational fears (i.e., those "not based on data") are not always easy to distinguish from rational (i.e., objective, data-based) fears; people believing an anticipated event to be dangerous will respond with fear whether objectively justified or not. So-called rational fears may be based on an objective view of reality, but that view may include reality as it is construed by the individual (e.g., as presented by the media). Thus, the distinction between objective and subjective reality can be indefinite and ambiguous, making it difficult to study only one or the other.

It was noted that risk assessment is affected by knowledge of the technology. Experts tend to view risk in terms of the probabilities of various adverse consequences and the expected numbers of individuals affected (e.g., injuries, fatalities). Lay people, however, more likely will see risk in terms such as equity, transfer of risk to other generations, and the uncertainty and catastrophic potential of short- and long-term consequences. While it may be less grounded in data, the typical lay person's view of risk is just as real in terms of the response and may in fact be, in the words of one expert, the "richer perception of risk."

Another factor affecting the extent to which risk is associated with nuclear power is the manner in which the technology and its associated risks are presented to the public. One of the participants noted that much of the public dialogue regarding nuclear power is in terms of "what if" (i.e., conjecture concerning a hypothetical future event) as opposed to the more objective "what is" (i.e., discussion based on the historical record of the technology).

In many discussions during the Workshop it was noted that nuclear power may be burdened with the fact that the stress symptoms observed in the environment of a nuclear power plant or after a nuclear accident may be falsely attributed to nuclear power. Responses to nuclear power also can be influenced by the predisposition and mental health status of the individual, so that there is no simple cause-effect relationship.

Lastly, the panel observed that the concept of risk is colored by political and ideological interpretations. Vested interests and belief systems may be involved in stated concerns over the risk of nuclear power. As an example, one participant observed that a portion of the public in the vicinity of a nuclear accident may believe they are under the influence of a cartel or conspiracy involving the nuclear industry, the utility, government agencies and the press.

2.1.5 Summary

Stress is only one of a number of potential psychological effects of nuclear power. A nuclear accident may directly cause reactions such as flight from the area or political action, which themselves may lead to more stress than the original event. Stress can be caused or aggravated by official concerns or delaying actions related to nuclear plants. Stress is not necessarily harmful and in some cases can be constructive.

The concept of nuclear power held by the public affects the psychological impact of a nuclear event. A common belief is that nuclear power is a risk or threat. This feeling stems from the facts, among others, that:

- The possibility for calamitous accidents exists.
- Nuclear power is felt to be an unknown and involuntarily imposed.
- The expert community appears to be in disagreement on the health, safety and risk issues.

Stress due to nuclear power, except in the early cognitive phases, leads to stress responses similar to those resulting from other events involving fear. Levels of stress and stress response, however, may be higher with nuclear accidents. Stress is closely tied to the assumed risk of nuclear technology. Whatever the accuracy of risk assessments, the stress they trigger is real and needs to be taken seriously. The assumed risk of nuclear power is also affected by the way the media presents the technology, by direct individual experience with the technology, by political and ideological positions and by the emotional health of the individual.

2.2 Studies of Psychological Stress in the Vicinity of TMI

In order that all the expert participants have the same data base from which to approach the Workshop objectives, a brief chronological review of the studies that have been done concerning individuals in the TMI vicinity was provided during this Workshop session by each of the expert participants that have been involved in this research. Due to constraints of time, presentations were limited and necessarily incomplete. For additional detail, not presented during the Workshop, review of the references noted by each researcher's name will provide more information. In order, presentations of TMI studies were made by Dr. George Warheit, Dr. Stanislav Kasl, Dr. Peter Houts, Dr. Evelyn Bromet, Dr. Andrew Baum, Dr. Dennis Mileti, and Dr. Victor Fongemie. Summaries of these presentations follow.

2.2.1 Dr. Warheit

Dr. Warheit* discussed data that had been collected by Kay Goldsteen as assisted by Victor Fongemie and others in the Pennsylvania State Department of Mental Health. He noted that the methods used for collection and analysis were not uniformly rigorous. Data were obtained on some of the psychological states (e.g., anxiety, depression, phobia) that are associated with demoralization (i.e., a broad melange of symptoms and dysfunctions). The study groups were: some large general population samples, a subgroup of mothers, and some rough probability samples obtained using telephone directories. There was one small comparison group consisting of patients being treated at one of the local community mental health centers. Over the course of data collection the individuals in this control group changed. Data were gathered for approximately four months beginning in April 1979.

In summary, the findings reported, based on analysis of the data collected, were:

- Immediately after the accident the rate of reporting of symptoms of demoralization in the TMI population was higher than that expected in a statistical probability sample in the general population. This rate did not equal but did approach the rate of reporting of demoralization symptoms in the patient control group.

*Dohrenwend, B.P., Dohrenwend, B.S., Fabrikant, J.I., Kasl, S.V., Warheit, G.J., Bartlett, G.S., Chisholm, R.F., Goldsteen, R.L., Goldsteen, K., and Martin, J.L.: Report of the Task Group on Behavioral Effects In: Staff Reports to the President's Commission on the Accident at the Three Mile Island. Washington, D.C.: U.S. Government Printing Office, 257-308, 1979.

- Over the sampling time of this study the incidence of demoralization in the TMI population dissipated and returned to levels expected in the general population.

- Indications of distrust of public officials were consistently higher than expected among the sampled TMI population. This persisted throughout the study.

2.2.2 Dr. Kasl

Dr. Kasl* reported the results of a study conducted among nuclear power plant workers. He noted that the results of such a study might be less applicable to the general TMI population because workers might be expected to bias their responses in order to be protective of the industry and their jobs. Roughly 600 telephone interviews were conducted approximately six months post-accident, about one-half among TMI workers and the remainder among workers at Peach Bottom, a nuclear power plant 40 to 50 miles away in a sociodemographically similar area. For purposes of data analysis the workers' positions were distinguished as supervisory or nonsupervisory. Targets of interest during data collection included:

- perception of workplace hazards,

- residual feelings (i.e., Now, six months after the accident, how do you feel about_____?)

- role conflict difficulties (e.g., remaining employed at TMI or moving family out of the area),

- behavioral changes (e.g., alcohol consumption, self-medication),

*Kasl, S.V., Chisholm, R.F.; and Eskenazi, B. "The Impact of the Accident at the Three Mile Island on the Behavior and Well Being of Nuclear Workers: Part I and Part II." American Journal of Public Health, 71, (1981): 472-495.

- effects on job satisfaction, and
- incidence of demoralization.

The findings concerning workplace hazards and their resultant effects on health indicated that, of approximately 12 topic hazards, the only difference between the responses given by the TMI workers and those offered by the Peach Bottom employees concerned believed exposure to radiation. At TMI roughly one half of the supervisory and nonsupervisory personnel felt they had been exposed to elevated levels of radiation during the accident and about one half felt that their health was endangered by the TMI-2 accident. With respect to residual effects (e.g., concern about living proximate to TMI, concern for the health of their children), the responses given by the TMI workers indicated dissipation of these concerns at the time of the interview (i.e., six months after the accident). The responses of the TMI workers confirmed significant difficulty with role conflict (e.g., staying home or moving away with their family versus going to work at TMI) but no significant increase in alcohol consumption, self-medication, or seeking professional medical attention. In their employment attitudes the TMI workers suffered clearly reduced job satisfaction and increased concern about their employment and the future of the nuclear industry. In addition, the supervisory individuals at TMI experienced decreased occupational self esteem and lessened identification with the company. In general, an elevation in demoralization symptomatology remained

among the TMI workers, primarily among nonsupervisory individuals, six months after the accident. Primarily among the supervisory personnel, the effect seemed to be increased if they had young children.

2.2.3 Dr. Houts

Dr. Houts* reported the findings derived from data gathered during the following random access dialing telephone surveys conducted by a professional polling organization:

- July 1979, interviewed about 700 people within 5 miles of TMI;
- January 1980, reinterviewed 400 of the 700 individuals from the July 1979 study (included use of the Langner Scale**);
- January 1980, interviewed 500 individuals separated into groups by distance from the plant (included use of the Langner Scale); and
- October 1980, conducted a study on mobility in the area, in concert with the Pennsylvania Department of Health.

In addition, data collected by NRC in an extensive telephone poll were analyzed. For some of the analyses, responses from a control group 40 to 55 miles away were used for comparison. It was noted that telephone interviews are hampered by the fact that it is not

*Houts, Peter, S., Goldhaber, Marilyn K.; "Psychological and Social Effects on the Population Surrounding Three Mile Island After the Nuclear Accident on March 28, 1979." Energy, Environment and the Economy, Chapter 14, edited by Majumelar, S., Pennsylvania Academy of Sciences, 1981.

**The Langner Scale was designed to differentiate mental health patients from the general population and correlates strongly with the demoralization scale.

reasonable to ask long or complex questions over the phone. In addition, care was taken to emphasize that these studies were general population surveys and, as such, the nature of the effects of TMI on vulnerable or highly affected subgroups in the population would not be expected to be apparent.

The findings of all these studies evaluated together generally indicate that the psychological stress phenomena evidenced 18 months after the accident are probably quite different from those apparent during and immediately after the accident. More specifically, a trend toward decreased concern is exhibited. When comparing the data gathered over time, it is apparent that, initially, people closer to TMI reported being more upset than those farther away. In January 1980 levels of upset still varied inversely with distance from the plant but the size of the difference had decreased. Responses obtained in October 1980 demonstrate no significant difference in level of upset associated with proximity to TMI. A similar trend was deduced when evaluating responses to the question of TMI being a serious threat. The people close to TMI revealed more concern than those farther away. The difference persisted over time, but the extent of the difference decreased over time.

With respect to behavioral (e.g., sleeplessness, irritability) and somatic (e.g., sweating spells, abdominal pain) symptom reporting, the group close to TMI retrospectively reported markedly higher incidences at the time of the accident. This effect persisted,

although the differences decreased, through January 1980. In October 1980 no significant differences in symptom reporting were found, when, as in the previous comparisons, the analyses were statistically controlled for age, sex, education and marital status. In addition, of the people reporting behavioral or somatic symptoms, those living close to TMI more frequently attributed them to the accident. This persisted even in October 1980 when the frequency of symptom reporting in the two groups was essentially the same.

When the Langner scale was employed to collect data in January 1980, no differences were found between the group proximate to TMI and the group distant from the plant. This finding is in general agreement with the findings using the demoralization scale reported by Dr. Warheit. However, it appears to disagree with the findings reported above by Dr. Houts for which direct symptom reporting was used. A comparison of the Langner Scale and the symptom reporting scale indicates a reason for this difference in findings. The symptom reporting scale only requires that a symptom be experienced during a two week period in order to be of interest; therefore, this scale is sensitive to small changes in symptom reporting frequency. The Langner scale, on the other hand, requires that the symptom be experienced often during a two week period in order to be of interest. Dr. Houts noted that symptom reporting, particularly this sort of casual symptom reporting, is subject to the affect of many factors other than having actually experienced the symptom.

During analysis of these data collected over time, Dr. Houts found changes in the characteristics of the concerned group. In his early surveys, the group most concerned could be characterized as primarily young as opposed to old, more highly educated rather than less educated and female rather than male. During later surveys, women still emerged as more concerned than men but individuals with less formal education were more concerned than those with more.

The surveys examined people's attitudes to restart of TMI-1. In January 1980 sixty percent of the people residing within five miles of TMI were opposed to restart, while in October of the same year opposition had decreased to 46 percent, a statistically significant reduction. Dr. Houts indicated that although levels of concern seem to be decreasing among the general population out to 55 miles from TMI, the levels have decreased at a faster rate among those living near TMI. When the group in opposition to TMI-1 restart in October 1980 was analyzed for age, income, education and sex, the only significant finding was that the group had an unexpectedly high proportion of women.

The final three findings reported by Dr. Houts concerned mobility, health care utilization and coping strategies. Although many people originally indicated an intention to move from the TMI area, no statistically significant evidence was found for mobility having been effected. Similarly, there was no significant increase in health care utilization rates even though people were reporting

increased somatic and behavioral symptoms. The responses to questions concerning coping strategies provided curious results. Apparently, individuals who were active copers (i.e., did something about their concerns) were more anxious initially and tended to remain more anxious over time than people who were not.

2.2.4 Dr. Bromet

Dr. Bromet* reported the findings of a study that focused on the following three research questions:

- Nine months after the accident, were there differences in the mental health of individuals living near TMI?
- Were there increased mental health problems at the time of the anniversary of the accident (i.e., March 1980)?
- To what extent does social support serve as a moderating variable for stress responses to the accident?

The study concentrated on the following three groups of people:

- mothers who had given birth during the 15 months prior to the accident and who also lived within 10 miles of TMI,
- nuclear workers who were members of one of the unions and working at the plant at the time of the accident, and
- patients who had been in the public mental health system within the six months prior to the accident who lived within ten miles of the plant.

*Bromet, Evelyn, et al. "Three Mile Island: Mental Health Findings." Prepared through support of NIMH contract #278-79-0048 (SM) Department of Health and Human Services, National Institute of Mental Health, Disaster Assistance and Emergency Mental Health Section, Oct. 1980.

These groups were compared with similarly structured groups from the area around the Shippingport-Beaver Valley nuclear facility in Beaver County. It was noted that since these comparison groups may have been stressed indirectly by the TMI accident, the results of the analyses may be considered conservative estimations of the impact of the accident among those living near TMI.

Face-to-face semi-structured diagnostic interviews were administered by mental health professionals, who were working at the time in the mental health field, had a relevant master's degree and at least five years of clinical experience in a mental health center. Interviews were conducted twice (i.e., nine to ten months after the accident and 12 to 13 months post-accident) and focused on two aspects of mental health. These were: 1) depression and anxiety that met research diagnostic criteria and 2) subclinical, manisfestations of stress as identified using the 90-item symptom checklist developed at Johns Hopkins (SCL-90). The interviews also included life history for psychopathology.

Analysis of the data provided by the interviews with the mothers indicated that there had been no differences in terms of clinical disorder rates between the two groups prior to the accident; however, in the year post-accident significant differences were observed in clinical depression and anxiety rates. The majority of the clinical episodes occurred during the two months immediately following the accident. Other than this difference in

rates, no other single predictor of clinical disorder was observed. There was a significant difference in subclinical symptomatology between the two groups of mothers, but none of the predictors except for living proximate to TMI correlated with the difference. One other variable did relate directly, i.e., history of psychopathology. Mothers who had had prior clinical experiences more often experienced clinical disorders after the TMI accident. With respect to subclinical symptom reporting, those who perceived their social support systems to be positive reported fewer symptoms.

There were virtually no differences in mental health found between the nuclear workers at TMI and those in Beaver County. In addition, no statistically significant differences in mental health were observed when comparing the two patient groups. There was a relationship between the concept of risk associated with living near a nuclear plant and symptom reporting by the patients. Those who believed it dangerous tended to be more symptomatic.

2.2.5 Dr. Baum

Dr. Baum* reported the results of studies concerned with the response of TMI area residents to the venting of krypton gas at TMI-2. A group of 44 people living within five miles of TMI served as the study group and a socioeconomically similar group from the

*Baum, Andrew; Gatchel, Robert J.; Fleming, Raymond; and Lake, C.R., Chronic and Acute Stress Associated with the Three Mile Island Accident and Decontamination: Preliminary Findings of a Longitudinal Study. Draft Report, submitted to NRC July 1981.

Frederick, Maryland area, 85 miles southwest of TMI, was used for comparison. Interviews were conducted four times:

- shortly before the venting, after the intention to vent had been announced;
- two weeks later, during venting;
- within a few days of the end of the venting; and
- six weeks after venting ceased.

As measurement methods, the SCL-90 was used to collect reported symptomatology, a proofreading task was administered to evaluate behavioral effects and a 15-hour urine sample was assayed for catecholamine levels to evaluate physiologic effects.

Results gathered and analyzed from the first interviews suggest the TMI group was experiencing anticipatory stress (i.e., they were reporting more symptoms, the intensity of some of those symptoms was greater, their proofreading performance was poorer, and their urine catecholamine levels reflected greater stress than in the Frederick, Maryland group). Once the venting began and until the last study, the differences reported initially began to decrease and continued to decrease for all but somatization, as measured by the SCL-90, and proofreading. For the most part, the differences observed between the TMI and control groups, with the two noted exceptions, were still significant at the last interview. However, the level of stress observed appeared to be mild (i.e., SCL-90 scores were considerably less than would be expected from a population of clinical patients, catecholamine levels were generally in the high

normal range and proofreading abilities generally were equivalent to those expected from college students immediately after being subjected to one-half hour of noise). The consistency and duration of the stress response was considered surprising.

Perceptions of threat and mistrust were also measured and, although the levels remained high, they correlated poorly with the other measures of stress. When queried concerning opposition to the venting, there seemed to be no real difference between the TMI and control groups (i.e., in both groups most people were moderately opposed, some extremely opposed and some in favor).

During the last interview two additional control groups were added. The first group lived near a coal-fired power plant in Maryland about 100 miles from TMI. The second group lived near an undamaged nuclear plant in New Jersey about 150 miles from TMI. These groups did not differ significantly from the original control group on any of the measures used, suggesting that the TMI responses were unique to TMI.

2.2.6 Dr. Mileti

Dr. Mileti* summarized a study of unobtrusive behavioral indications of stress (e.g., alcohol consumption, automobile accidents, suicides, psychiatric admissions) among three groups

*Mileti, Dennis S.,; Hartsough, Donald, and Madsen, Patti. "The Three Mile Island Incident: A Study of Behavioral Indicators of Human Stress" draft report prepared for Shaw, Pittman, Potts and Trowbridge, Legal Counsel to General Public Utilities and Metroplitan Edison, 1981.

(i.e., people living within 5 miles of TMI, people living 5 to 10 miles from TMI, and people in a demographically similar area of Pennsylvania).

The summarized findings were that the major indicators (e.g., suicide, psychiatric admissions) did not reflect a significant stress response, but that the minor indicators (e.g., alcohol consumption) did suggest a low level stress response. The response observed was of short duration and was considered similar to the stress associated with a major holiday.

2.2.7 Dr. Fongemie

Dr. Fongemie* reported the findings of a study that had been done through Hahnemann Medical College. They were:

- The people at TMI had a considerable lack of faith in the information they received during the crisis.
- People at TMI acted reasonably well on the basis of what they believed to be true and how they felt about it.
- There was a significant amount of stress and psychological discomfort among the people proximate to TMI.
- People at TMI acted rationally.

2.2.8 Summary

There was an increased incidence of somatization observed in the general TMI population immediately after the TMI-2 accident. These symptoms were generally found more frequently and at greater

*Morell, Jonathan A.; Spivak, George. "Review of Studies on the Psychological and Behavioral Impact of the TMI Nuclear Accident with Specific Implications for Research and Planning, draft report, Department of Mental Health Sciences, Hahnemann Medical College, 1980.

levels among individuals living closer to TMI. The groups exhibiting most concern often had a greater than expected proportion of women. With the passage of time since the accident, symptomatology generally decreased in frequency and extent, although reporting was still elevated above expected levels in one study as much as seventeen months after the accident. As long as 18 months post-accident people living near TMI were attributing reported behavioral and somatic symptoms to the accident, although their rate of symptom reporting was essentially the same as a control group that did not attribute symptoms to TMI. The TMI population responded to another nuclear-related event (i.e., venting of krypton gas) with anticipatory stress and with low level but long lived stress after the venting ceased. Perceptions of TMI as a threat and distrust of public officials persist.

2.3 Concepts, Causes and Consequences of Stress Which May be Applicable to the TMI-1 Restart

The purpose of this session was to provide the expert participants an opportunity to discuss possibly conflicting concepts of stress and to identify causes and consequences of stress they have observed or have become acquainted with in the literature. The members of the Workshop identified and discussed the similarities and dissimilarities of the TMI situation with other stressful situations that have been studied. Blame behavior, coping style and political activism were discussed. The nature of the acute stress response at TMI was outlined and the possibility of the emergence of a chronic disabled group suggested.

2.3.1 Differences Between a Natural Disaster and the TMI-2 Accident

Considerable discussion centered around the differences between natural disasters and the nuclear accident at TMI-2. After a natural disaster the cause is usually concrete and relatively clearly understood. The worst is over quickly, the process of definition of damage gets underway and the community unites and begins to allocate resources for recovery activities.

In contrast, the nuclear accident at TMI-2 was not bounded in space and time. At the time of the accident, the various experts and information sources disagreed on the extent and danger of exposure. Because of the intangible nature of radiation and radiation damage, people did not know whether they had been harmed; they were aware that the effects of radiation may be delayed many years and are uncertain. If people left the area, they might be taking personal damage with them rather than leaving it behind.

One participant in the Workshop described the difference in arrival at the site of a natural disaster and arrival at Harrisburg five days after the accident. In the TMI area, there was no visible damage and no community consensus about damage or the options for recovery. The predominant response, if any, was flight. either actual or anticipated. Those persons living near the plant had been faced with the choice of joining the precautionary evacuation without solid information on which to base their choice. There was no option for physical involvement in the process of recovery from the event, as there is after a natural disaster.

Additional observations concerning the similarities and differences between TMI-2 and natural disasters were made, including:

- The person who lives in an earthquake zone and the person who lives near a nuclear power plant may both experience stress. This stress may be revived or increased on a continuing basis by the reports of earthquakes or nuclear incidents elsewhere.

- An earthquake is not in the realm of human control and political activity is not effective in averting one. A power plant accident, in contrast, is a consequence of human economic activity that can be affected by the political process.

The participants in the Workshop suggested that a critical aspect of the TMI-2 accident was the lack of problem definition and resolution. As noted, the extent and implications of exposure were undefined in the public mind, but dreaded. People who believed they had been exposed also fear that they carry the damage around within them and that the results of that damage may not become apparent for many years. Various analogous situations were suggested:

- exposure to chlorine gas during World War I;

- post-World War II exposure of military personnel in atomic tests;

- exposure to Agent Orange during Viet Nam;

- exposure to toxic waste sites, such as the Love Canal; and

- the period after internal trauma, such as a heart attack.

While none of these analogies was seen as identical to TMI-2, they had in common an event or situation of uncertain future outcome that was considered potentially stressful to the individual.

2.3.2 Group Efforts to Define the Problem

After a natural disaster, the dominant mode of community response is the definition of damages and the allocation of resources for recovery. It was suggested that after a technological disaster, a protest group may be performing a similar function: seeking to define the problem and providing a focus for community organization.

The people at TMI who were most strongly opposed to nuclear power also tended to prefer that the nuclear decision-making process be vested in the political arena rather than in the technical experts or agencies. The genesis of a protest group after a technological disaster should probably be expected because of the need to define the problem and propose a community course of action. Additionally, because the event provides a "cause" to rally around, some individuals who do not actually have strong feelings, may be drawn into the protest.

The Workshop also addressed differences in blame behavior and coping as related to psychological stress. After a natural disaster, if any blame is to be allocated, it is more readily directed towards oneself by defining the problem as having to deal with "my own emotional responses." After a technological disaster there are man-made causes that can be identified and blamed. Some people, therefore, may focus blame outward and not come to terms with their own feelings.

People also vary with respect to coping style. Although it might be predicted that it should be easier to deal with an external source, evidence was presented to the contrary. Those who approached the TMI accident with a problem-solving orientation as contrasted with an emotion-resolving orientation showed higher levels of frustration and stress. It was noted that the resolution of a problem in the political arena is often difficult, frustrating and long-term. This approach may, in fact, perpetuate the lack of resolution of the stress. (Clinical practice has shown that people who try to deal, for example, with fear of flying by dealing with the external reality [e.g., FAA or air safety issues] rather than with their own emotions, will show continuing frustration and lack of conflict resolution.) Failure to gain attention and to achieve political objectives may lead to depression and a feeling of helplessness.

2.3.3 The Acute Stress Response

Participants felt that the acute stress response is a normal expected response to a stressful event and, therefore, is not necessarily pathological or a disorder. The physiological indicators of anxiety and depression may be expected to peak initially and then taper back to baseline levels as resolution is achieved. This pattern was observed after TMI-2 with two important qualifications. First, for the majority of the population the measured levels of stress symptoms, even initially, were relatively

mild and have since fallen to levels that, although low, still appear to be above normal or expected levels. Second, there are indications that this elevated but low level of stress has been maintained over a surprisingly long period of time.

The bulk of the stress literature deals with apparently acute stress responses that are resolved relatively quickly. The physiological and psychological effects of long term maintenance of low level stress are not known. One possible analogy mentioned at the Workshop is prisoner-of-war situations, in which victims are in an unresolved situation for years at a time. Assessment of the psychological impacts of these situations is, however, usually additionally complicated by nutritional deprivation and physical torture. It was suggested that the traditional stress model of depression/anxiety/resolution that guides research projects may need to be modified to include indices of chronic degenerative processes.

Concern was also expressed that high risk groups in the population be identified and studied. These may be groups that are apt to have been more highly stressed in the original event (e.g., women pregnant during the accident) or are apt to maintain a long-term but mild level of stress (e.g., political activists).

2.3.4 The Chronic Disabled Group

Some of the participants in the Workshop hypothesized that a chronic disabled group may be expected to emerge over time. Membership in this group may be different from membership in the

acute stress group. In fact, the emergence of a person as chronically disabled may not be related to severity of the initial exposure. For example, exposure to Agent Orange initially produced a dose-related skin response. The chronic disabled group that later emerged showed no clear correlation with the extent of initial exposure.

Members of the chronic disabled group may or may not be exposed to any more stressful life events than the general population, but they have personalized interpretations of these events. It was hypothesized that they generally function in support groups that are unusual or impoverished. Sometimes they have a history of psychological problems and often have a number of other concurrent life problems.

The expert participants suggested that stress is multi-factoral; many events contribute to the level of stress an individual experiences at any one time. Many of these stressful events are family- and job-related. When a person is identified as a member of a chronic disabled group, it is difficult to say what particular causes of stress pushed them beyond their ability to cope with stress. The participants in the Workshop were not able to predict whether any chronic disabled group that may emerge in the TMI population will be any larger than it would have been in the absence of the TMI-2 accident.

Although stress related to the TMI-2 accident, or to the possible restart of TMI-1, is but one of the factors or life stresses that might have contributed to the emergence of any chronic disabled

individuals, there is likely to be fairly high level of attribution of that condition to the TMI-2 accident or to the restart, should it occur. People who are chronically disabled characteristically identify an event to explain their condition. The attribution of chronic disability to the TMI-2 accident or to the restart of TMI-1 was suggested by one of the participants as a potential future legal problem.

2.3.5 Summary

The TMI-2 accident was characterized by uncertainty of the damage and lack of resolution. The resulting stress was compounded by the fear of nuclear accidents and the long-term but hidden effects of radiation damage.

Acute stress responses have been observed at TMI. These normal responses to a stressful situation were, for most, initially relatively mild and have since declined to low, but slightly elevated, levels. The implications of these mild but long term stress levels are not known.

A chronic disabled group may be expected to emerge over time. This group, probably different in membership from the groups originally manifesting stress, is thought to be characterized by many life problems and is likely to attribute disability to the TMI-2 accident.

2.4 Evaluation of Methods Used in Identification and Measurement of Stress and Stress Responses

The purpose of this Workshop session was to provide the experts with an opportunity to evaluate critically and systematically the

various stress identification and measurement methods employed, particularly those they have used. It was noted by one of the participants that the National Academy of Science has recently completed and published a comprehensive evaluation of methods used in the identification and measurement of stress responses. Therefore, the discussions during this session focused on the goals for identification and measurement, an assessment of the various research approaches and methods, and problems and issues encountered in identification and measurement of stress responses.

2.4.1 Potential Goals of Identification and Measurement

The expert participants identified five major goals for identification and measurement:

- Determine the proportion of stressed individuals in the target population as compared to baseline and control populations.
- Measure or infer the level of stress.
- Measure the outcomes of stress. It was suggested that typically these have been anxiety, depression, or psychophysiological symptoms but may have to be broadened to include chronic degenerative states and perhaps some quality of life measures.
- Identify specific high risk subgroups within the target population.
- Describe the evolution of stress-related impacts and gain some insight into process dynamics.

2.4.2 Consideration of Multiple Method Approaches

The members of the Workshop agreed that the use of multiple measures and methods by a variety of investigators is the most desirable approach to analyzing stress responses. Stress research

is a demanding discipline with complex varied responses and without precise measures. Each method used has its own shortcomings; but, when used together, methods may provide a convergence or a consensus in the major findings. It was felt that when a trend is found by a number of research approaches, the research community can be far more certain of the validity of the finding. To a certain extent, such has been the case in the TMI-2 studies. For instance, the persistence of the stress response was noted as surprising to the TMI-2 researchers, but the finding was verified by several studies. When a consensus is not found, the results of each approach are judged on their own merits rather than discounted. Where results conflict, attention may be focused on what is being measured and what intervening variables may be affecting the findings. Lack of consensus or appearance of conflict does not suggest necessarily that one or both findings are in error, but careful interpretation of the result is essential.

The participants noted that agreement between the various measures of stress should not generally be expected, especially when evaluating relatively low levels of stress. Different people respond to stress in different ways. One measure will pick up one type of response, another measure another type of response. Only when the level of stress is quite high might several of the various indicators of stress be manifest concurrently. In fact, it was suggested that agreement between the results of various measures may be an indication of severity of stress.

2.4.3 Comment on Specific Methods

The participants discussed a variety of research designs and measures and indicated some of the strengths and weaknesses of each. Specific discussion concerned probability samples, subgroup studies and longitudinal studies. Self-report measures, physiological measures and quality of life measures were also discussed.

The probability sample may be the sampling technique of choice if adequate funds are available. Statistical sampling from the affected population allows the findings to be generalized back to the population as a whole. The participants noted that a large sample will be required, particularly if multiple measures are to be used and if the level of stress is relatively mild. This method is appropriate to answer questions such as "What are the impacts on people living within the five mile radius as compared with another group?" Large scale sampling also may be used as a screening tool in an effort to identify subgroups that may be at particularly high risk. This method, however, is not useful for describing the high risk groups themselves and will not necessarily permit all high risk subgroups to be identified. Rather, generalizations can be made only to the overall population.

Detailed study over time of a high risk subgroup may allow observation of the evolution of the stress response or impacts in those particularly affected. To identify high risk subgroups for

further study an a priori judgment of which groups are particularly vulnerable must be made or some clustering method must be employed based on data from larger scale studies. It was suggested that when funds are constrained, the best strategy may be to focus attention on those groups that are believed to be most susceptible to the effects of stress.

Longitudinal studies are needed for tracking changes over time and describing the process of resolution of acute stress and the possible emergence of a chronic disabled group. The problem pointed out by the participants is that these studies usually lack adequate baseline data. In general, a population studied after a disaster has been inadequately characterized before the disaster. As a result, there may be a tendency to attribute stress to those individuals in the population whose stress indicators do not return to baseline. Whether these individuals are stressed or simply have a high normal value for a particular measure cannot be determined without the baseline data.

Self-report studies and field interviews are commonly used methods for obtaining prevalence and incidence data. However, caution was recommended when relying on findings based on self-report data, because of the following biases that are difficult to control:

- The people being interviewed may respond with answers believed to be desired, rather than with answers that reveal what they really think.

- The people being interviewed may falsify their responses for manipulative purposes (e.g., political or ideological motivations).

- Recollection of past events may be unconsciously biased by more recent events or attitudes.

- People may attribute causality that is not warranted.

Well-conducted interviews and well-constructed field instruments usually have built-in checks to counteract some of these biasing effects. Some participants in the Workshop suggested that it would be appropriate to supplement the self-report data with the use of non-self-report measures.

A number of interview instruments are widely used. The diagnostic interview schedule (DIS)*, for instance, is being used by the National Institute of Mental Health in a number of large-scale studies. The common use of instruments like DIS among studies may allow comparisons of populations in one study with populations in other studies.

Physiological measures were felt to be useful in avoiding the bias problems of self-report measures. However, some of the expert participants noted that the high degree of individual variation often renders these measures as inadequate as psychological measures of stress. Covariation between physiological and psychological measures is greater when used to describe impacts of higher levels of stress. At higher levels of stress these physiological measures may be useful for assessing magnitude of the stress impact.

---

*A structured interview, focusing on historical and current psychological states, that can be administered by a lay person.

The members of the Workshop considered quality of life measures but found it difficult to tie these measures into the traditional concepts of stress. It was noted by some that a sense of well being is certainly part of the quality of life, but that stress measures should go beyond opinions, feelings and political objectives, factors which quality of life indices tend to reflect. It was also noted by one of the participants that quality of life measures should have some correlation with physiological measures if they are to be considered measures of health. It was suggested that support groups and networking be studied to determine their role as stress-related indicators of quality of life. Another participant felt that measures of psychological health might well include purely psychological considerations, without concomitant physiological manifestations.

2.4.4 Other Problems and Issues

The identification of high risk groups generally has been done on an informed but a priori basis. The identification of individuals within that group who may be particularly vulnerable is difficult. Some of the reasons for this difficulty are:

- Individual differences exist in psychological and physiological makeup. People exhibiting a high level of stress on any given stress measurement, in fact, may be highly stressed or may be exhibiting a high, but for them normal, level.
- Differences in coping behavior affect the extent and rate to which stress is expressed and/or resolved.

- Differences exist in the number of variables that lie between the stressor and the stress responses or impacts. This includes differences in perception, differences in support groups and, for children, differences in developmental stage.

- An individual may be experiencing other stresses concurrently, of which the investigator is not aware. Stress may be cumulative and the individual response observed may be affected by stresses other than those the researcher has defined.

2.4.5 Summary

The members of the Workshop agreed that multiple measures and methods are needed to evaluate stress responses. Each of the major measurement approaches, including probability samples, subgroup studies, longitudinal studies, self-report measures and physiological measures, was found to have advantages and imperfections. Although each approach has its own problems, when a consensus is found among various studies using multiple measures, confidence in the finding is increased. The members of the Workshop also agreed that they do not expect the various psychological and physiological measures of stress all to agree with each other. In fact, when they do, that is generally taken as an indication of severity of the stress.

Goals for measurement include information on the incidence and severity of stress within the population, identification of high risk subgroups and insight into the process dynamics of stress. The traditional measures of stress impacts may need to be broadened to include chronic degenerative states and some appropriate quality of life indicators.

2.5 Ability to Extrapolate From Existing Studies To TMI-1 Restart

The purpose of this session was to evaluate the extent to which existing knowledge and data on psychological stress provide a basis for predicting stress in the event of a restart of TMI-1. Three major topics were discussed: caveats associated with extrapolation, the scope of extrapolation, and assumptions and approaches for extrapolation.

2.5.1 Caveats Associated with Extrapolation

Many participants stated that generalized predictions can be made; however, the limitations of social science theory and methodology, as well as inadequate data, are likely to yield predictions in which they would not place a high degree of confidence. Indeed, the fact that several unanticipated results were found in the stress studies on the TMI-2 accident was discussed. Reference was made to findings such as the unexpected longevity of the stress after the accident, followed by a decline to normal or nearly normal levels. Elevated rates of somatization as much as six weeks after the venting of krypton gas also was pointed out as an unexpected finding. Given their expectation of a low level of confidence in extrapolations, participants prefaced their comments with the following caveats.

First, predicting future behavior is very difficult. The degree of difficulty rises as the dissimilarity between known events from which extrapolations are to be made and the potential event

increases. A restart of TMI-1 may have no real parallels since people living in the vicinity of TMI already have experienced a nuclear accident and thus constitute a population sensitized to stress. Post-accident stress following the TMI-2 incident or a natural disaster may be quite different from anticipatory stress which may accompany a restart of TMI-1. (Stress associated with the krypton venting may be more analogous to a TMI-1 restart.)

Second, knowledge about the TMI population, while more complete than that available for most populations, is not sufficient. There are no baseline, pre-accident data on this population, and the post-accident data are incomplete. Moreover, few data have been collected specific to the potential restart of TMI-1. For example, it would be useful to understand the perceptions of residents regarding the competence of TMI-1 managers and operators and residents' evaluation of the possibility of future accidents. The data that do exist on the TMI population come primarily from descriptive studies of responses to the TMI-2 accident. These studies were not designed for prediction.

Third, even if data on the potential restart of TMI-1 were collected, inferences from them would be problematic. Many of these data would be obtained from survey instruments which require people to anticipate their feelings should TMI-1 reopen. Responses may be biased both by the inability of people to predict accurately their future feelings and behavior and by deliberate misrepresentation

designed to influence the restart decision. The participants referred to classic studies of the inability to relate intentions to behavior, as illustrated by the work of Harding and Logreth on the topics of racial prejudice and integration. These studies suggest that while people may state their opposition to a situation and indicate a refusal to participate, many in fact do participate. Similarly, studies of toxic waste dumps and nuclear reactor siting have shown that the hostility of residents declines significantly within a year after installation of the facility. Thus, asking people about their expected reaction to a reopening of TMI-1 may provide data too unreliable for prediction.

Fourth, social science theory currently does not permit a complete enough understanding of psychological stress phenomena associated with past and potential TMI events. A consequence of this is that statistical analyses are difficult to carry out and interpret. A multiplicity of factors affect stress at TMI, confounding identification of the most important causal variables. In addition, statistical artifacts may be complicating the interpretation of existing data specific to the TMI-2 accident. Another consequence is the inability to adequately characterize or fully anticipate certain stress responses. A particular concern is the physiological effects of long-term, low-levels of stress on the TMI population. This type of stress may have unique aspects, distinguishing TMI from transient stressors (e.g., earthquakes);

yet existing literature on this issue focuses instead on the physiological effects of short-term stress. It was pointed out that it would be logical to look for degenerative processes such as increased blood pressure that result from being in an unresolved state for a prolonged period of time. Similarly, a chronic disabled group may emerge but this possibility is not well documented. Suggested analogies of low-level, long-term stress may be found in soldiers exposed to chlorine gas in World War I and to Agent Orange in the Viet Nam War. The literature on these events may be an important source of information.

2.5.2 Scope of Extrapolation

In light of these reservations, participants made a series of comments on the possibility and scope of extrapolation. It was commonly agreed that plausible guesses or general predictions can be made, albeit with large errors and variances expected. Participants also agreed generally that responses to the TMI-2 accident and krypton venting bound the upper range of responses expected to a restart of TMI-1, with restart probably being less stressful than the TMI-2 accident and more comparable to the venting. It was argued that it should be possible to identify the most important variables for predicting psychological stress. Participants were not in agreement, however, regarding what the most important variables are. Data collected on responses to the TMI-2 accident and the venting of krypton gas were identified as the basis from which any extrapolation should proceed.

It was argued that responses to a threat have a common core of biological and psychological reactions which are qualitatively the same regardless of the source of the threat and that responses will not be different for the TMI population. The incidence of acute stress can be measured and predicted with much greater confidence than that of chronic stress. Moderate responses are more difficult to predict than extreme responses. Most groups particularly vulnerable to acute stress can be identified, and the temporal character of that stress predicted. Predictions of the time pattern of acute stress will be more accurate if no problems or disturbances accompany a TMI-1 restart.

Participants emphasized the value of using existing data specific to the TMI population in making extrapolations. Opinions differed regarding the validity of extrapolating from the general body of disaster and transient stress literature. Three arguments emerged. One was that TMI events are not qualitatively different from natural disasters; thus, extrapolation from the disaster literature is appropriate. A second argument was that the TMI-2 accident is too minor to define as a disaster; hence, extrapolation from the disaster literature will overestimate the stress of a TMI-1 restart. A third argument was that as a sensitized population exhibiting a number of unanticipated, if not unique, stress responses, TMI residents' stress associated with a restart of Unit 1 cannot be analyzed appropriately via extrapolation from natural disaster or transient stress literature.

2.5.3 Assumptions and Approaches for Extrapolation

Participants pointed out that extrapolations to a TMI-1 restart should be grounded in several specific assumptions. These assumptions, in turn, help define approaches to extrapolation, and in some cases, indicate further uncertainties. Assumptions and approaches discussed included statistical distribution of the stress response, the effect of past stress on the TMI population, parameters that identify high risk populations, assessment of the chronic disabled and the role of intervention to mitigate stress.

The stress response is assumed to be normally distributed. Some participants maintained that the proportions of response types (i.e., those severely affected as opposed to those mildly affected or unaffected) would be similar to proportions found in the disaster literature. Others disagreed strongly with statements about proportions. The mean of the distribution or average stress level is assumed to be a function of the competence with which a possible TMI-1 restart is effected: technical problems or vocal opposition will tend to increase the mean. It was noted, however, that even the occurrence of a subsequent accident does not necessarily mean that the process of accommodation will cease.

The TMI community is assumed to be sensitized as a result of the TMI-2 accident. Consequently, incidents in the nuclear power industry outside the TMI vicinity are expected to affect the level of stress and, therefore, nuclear power should be included as an

independent variable in a stress assessment. As a sensitized population, the TMI community is assumed to have had its ability to cope with additional stress affected. The participants disagreed as to whether coping ability was enhanced or impaired as a result of the accident.

Certain subgroups are expected to be most vulnerable to acute stress, but there was not general agreement about the characteristics of these groups. It was suggested that some high risk groups could be identified by social and demographic characteristics and might include those living closest to the power plant, women pregnant during the accident, and women and men with small children. It also was suggested that attitudes toward authority, nuclear power and the reopening of TMI-1 may be correlated with stress responses should TMI-1 reopen. Because much of the data on TMI is based on general population surveys, which may mask a significant effect distributed among a small segment of the population, none of the participants was confident that all high risk subgroups can be identified.

A group that will be particularly difficult to analyze but important to understand, according to some of the participants, is the chronic disabled. This group is expected to emerge over the longer term, after most people with acute stress responses have resolved their problems. Given the present knowledge base, a priori identification of those at high risk for the chronic disabled group

will be difficult using demographic data and prediction of the incidence of chronic disabled onerous. How chronicity may alter symptomatology is not clear. Agent Orange studies suggest that chronic stress response tends not to be proportional to the extent of exposure to the stress agent. It was opined that the chronic disabled are usually people who have concurrent life problems and whose past history of personal difficulties predisposes them to this response to cumulative stress. A particular problem with regard to any chronic disabled is establishing whether a link actually exists between their later disability and the TMI-2 accident or the restart of TMI-1.

Some participants suggested that extrapolation be conditional upon intervention. That is, it could be assumed that interventions to mitigate the stress of restart will be helpful. Extrapolations and predictions of stress response then would be made based on the assumption that specific interventions will be used.

2.5.4 Summary

Generalized predictions about stress associated with a TMI-1 restart can be made, but possibly without a high degree of confidence. Several caveats should be observed if predictive efforts are undertaken. Caveats include:

- Dissimilarities between a TMI-1 restart on the one hand and prior TMI-2 events and natural disasters on the other will make predictions uncertain.
- The data base on the TMI population is limited, especially with respect to attitudes toward TMI-1 restart.

- The relationship between expressed attitudes toward restart and future stress responses is problematic.
- Social science knowledge of the effects of long-term, low level stress is limited.
- An insufficient understanding of causal variables impedes interpretation of statistical data.

Responses to the TMI-2 accident and krypton venting are believed to bound the upper range of responses to a restart of TMI-1. The incidence of acute stress can be measured and predicted with some confidence, most groups particularly vulnerable to acute stress can be identified and the temporal pattern of that stress can be predicted. Generally, the qualitative severity of the acute stress response can be predicted. The theoretical and empirical body of knowledge on any chronic disabled group is much less developed, and prediction of chronic stress is highly uncertain. Data specific to TMI will be more important for extrapolation than will be the disaster literature.

The following assumptions will facilitate extrapolations:

- The stress response to a TMI-restart will be normally distributed.
- The population's coping ability has been affected by the accident.
- Specific subgroups will be more vulnerable to stress.
- A chronic disabled group may emerge over the longer term.

2.6 Technical Considerations for Predicting Psychological Stress Associated With a Restart of TMI-1

In this session participants were asked to discuss the factors they would consider in conducting an assessment of the psychological impacts of reopening TMI-1. They were instructed to assume that the assessment would begin immediately and that predictions of stress could be based only on existing data and information. Topics addressed in this session, then, were approaches to predicting, with the existing data base, the psychological stress associated with a restart of TMI-1 and factors affecting the confidence with which such predictions can be made.

2.6.1 Approaches to Predicting Psychological Stress Associated with a Restart of TMI-1

It was noted previously that participants felt that responses to the TMI-2 accident and the venting of krypton gas bound the upper range of stress responses expected to a restart of TMI-1. Stress responses to a TMI-1 restart are expected to be lower in magnitude than those associated with the accident. As such, the approaches suggested in this session emphasized the use of the most recent data and literature available, particularly data specific to TMI-2, including the data on the venting of krypton gas. Participants noted that in addition to the results of TMI studies presented by researchers in the second session of the Workshop, a body of unanalyzed TMI data exists, which should be applied to an assessment of a TMI-1 restart. Participants also referred to on-going studies of the TMI population which would be relevant to an assessment.

Participants observed that important data in assessing a TMI-1 restart are the attitudes of the TMI population to this potential event. Although research has not focused on the issue thus far, a number of questions about restart have been asked in the various TMI studies. Responses to these questions represent the best information available about attitudes toward restart. It was suggested that data on opposition to restart be examined to distinguish between activist opponents and those whose opposition is evidenced primarily in their responses to surveys. Additional data believed to illuminate the issue are the feelings of the TMI population about nuclear power in general. Such information also is contained in the existing data base. Another important use of the TMI data base is for identification of the characteristics of people who were most highly stressed from the TMI-2 accident, on the assumption that similar types of people are more likely to be highly stressed should TMI-1 be restarted.

One suggested focus for analysis, insofar as TMI-2 data permit, is to determine whatever meaningful correlations exist between feelings of distress due to the TMI-2 accident and opposition to reopening TMI-1. Related to this is whether there is a correlation between opposition to nuclear power and stress from the TMI-2 accident. It was pointed out, however, that correlations of this nature may derive in part from false attribution -- unconscious or

deliberate -- of symptoms of stress to the TMI-2 accident. Results of analysis of TMI data to date are mixed concerning the strength of these correlations.

Another area requiring emphasis is subgroup analysis. It was suggested that groups shown to be vulnerable to stress from the TMI-2 accident be examined in more detail to help explain the characteristics and dynamics of their stress. It also was suggested that the existing data be analyzed to identify clusters of problems and then to link these problems to subgroups. Participants agreed that the existing data base may not permit complete identification of vulnerable subgroups.

Participants indicated that in analyzing the existing TMI-2 data, they would seek to identify consistent results across studies as well as to identify similar ambiguities or inconsistencies across studies.

It was pointed out further that in analyzing TMI-2 data, attention should be given to the time trend of behavior, primarily to provide an understanding of the changes in acute stress responses over time. The time trend optimally also would indicate whether a chronic disabled group is emerging. However, the fairly limited time frame of existing studies, types of sampling procedures employed, and a less comprehensive understanding of this stress response are likely to preclude identification of any chronic disabled group from existing TMI data.

Although focus on the TMI data generally was agreed to be the best approach for predicting the stress of restarting TMI-1, three additional suggestions were made. The first two concerned ways of supplementing the data base and filling in gaps, and the third recommended a specific starting point.

First, indirect data, such as that collected by Dr. Mileti, may be used to assess the stress of TMI-2. This includes data on alcohol consumption, absences from work, automobile accidents, and political action. While some participants felt that this information would be useful for predicting stress, it also was argued that it can be used only for monitoring purposes.

Second, the disaster literature was viewed as secondary in importance to specific TMI-2 data but nevertheless useful for general information and filling gaps. The area in which it would have to be the principal source of information is for assessing any chronic disabled. Participants concluded that neither the literature nor the data will permit a satisfactory assessment of any chronic disabled group.

Third, it was suggested that contrary to the majority's emphasis on data, the process of prediction should begin by studying existing theory to determine the most important causal factors. From this, researchers will be better prepared to evaluate the relevance of existing data and literature.

Several participants observed that the stress of not reopening TMI-1 is as important to assess as the stress of reopening the unit,

since that, too, is an action with associated stresses. A psychological consequence of not restarting TMI-1 may be to confirm that nuclear power is very dangerous: the idle plant will remain in the community and be a source of stress, perhaps even more severe a stress than a reopening. It was noted that the phobia literature suggests that people who do not confront their fears suffer greater distress. In contrast, it was argued that persons with a real phobia to restart could be desensitized by a restart; but, if their fear is radiation, they cannot be desensitized, and restart may sustain the fear.

Not reopening TMI-1 will have economic consequences, which have potential for leading to psychological stress. Parties at risk for economic and related psychological stress should TMI-1 not be reopened include utility employees, utility stockholders and ratepayers. An analogous situation may be industrial failures, e.g., Studebaker. Studies of psychological stress of unemployed workers were suggested as a data source. It was pointed out, however, that the electric utility industry may be unique in terms of the impacts of failure.

Finally, it was argued that any assessment of psychological stress associated with a restart of TMI-1 be conducted and presented in the context of other stresses. If this is not done, the likelihood is high that the potential for stress of this event will be exaggerated and that the studies themselves possibly could exacerbate the stress.

2.6.2 Factors Affecting Confidence in Predictions

Participants felt strongly that predictions be accompanied by the researchers' degree of confidence in the results. The possibility was raised that the uncertainty of the predictions could be so high that they would not be willing to make them at all and that low-confidence predictions could be harmful. Data and methodological limitations that tend to reduce participants' confidence in predictions carried out without the benefit of further research were discussed.

First, the studies done on TMI-2 are descriptive and were not conducted for purposes of prediction. Thus, they do not address all necessary questions, and they do not permit statistical testing of significance and confidence for many results important for predicting the stress of a TMI-1 restart.

Second, while TMI-2 data are helpful, the reopening of TMI-1 and the TMI-2 accident and krypton venting are different events. Moreover, the accident has transformed the TMI population. Yet extrapolation from existing data requires the assumption that the response to a restart will be similar to the response to the accident or to the venting of krypton gas, implying a close similarity of events and populations.

Third, techniques for identifying people at high risk are not satisfactorily developed. The potential for emergence of a chronic disabled group certainly cannot be treated adequately due to the

paucity of both theory and data. Techniques for identifying other high risk groups also may be inadequate. It was argued, for example, that men and women often evidence stress in different ways and that existing stress evaluation instruments tend to detect stress in women more frequently than in men. Methodological weaknesses of this type may cause underestimation of the stress experienced by the population as a whole and by specific groups.

2.6.3 Summary

According to the participants, existing data specific to TMI-2 offer the best basis for predicting the psychological effects of a TMI-1 restart. Analysis of these data should focus on the following factors:

- attitudes toward a TMI-1 restart,
- identification of subgroups highly stressed from the TMI-2 accident,
- possible correlation between opposition to nuclear power and TMI-1 restart and stress, and
- changes in stress over time.

Examination of the theory of stress will permit a better evaluation of the data. Indirect data (e.g., alcohol consumption, absenteeism) and relevant disaster literature are of secondary importance to TMI-specific data but are useful for general information and filling gaps. The exception is for assessing the incidence and nature of any chronic disabled individuals. Here the literature appears to be the best, perhaps only, source of information in terms

of both theory and data. The stress of not restarting TMI-1 should also be considered.

It is important that predictions be made with adequate confidence. The following data problems and methodological weaknesses tend to reduce confidence in predictions:

- TMI-2 studies are descriptive, not designed for prediction.
- Predictions require assumptions that events and populations associated with the TMI-1 restart are similar to those associated with the TMI-2 accident or krypton venting.
- Techniques for identifying high risk subgroups may be inadequate.
- Existing theory and data preclude satisfactory assessment of any chronic disabled group.

2.7 Identification of Additional Near Term Efforts Needed to Fill Gaps in Existing Concepts and Studies

One of the outcomes of many discussions during the Workshop was an indication concerning the need for additional research and analysis in order to increase confidence in any predictions of psychological stress that may be associated with a restart of TMI-1. The expert participants were asked during this Workshop session to focus on needs that might be fulfilled in the near term (i.e., within the next 6 months). In addition, they were asked to indicate what benefit(s) might be gained, in terms of increased confidence in their predictions concerning the stress associated with a TMI-1 restart, by performing the additional research and/or analysis.

2.7.1 Near Term Efforts

In responding to the question of additional near term research needs, the thoughts of the expert participants and expert observers generally fell into two areas. The first concerned specific research and analysis to be done:

- reanalyze existing TMI data, evaluate some as yet unanalyzed TMI data, and gather new TMI data; and
- conduct a focused review of the existing non TMI literature.

The second area concerned other perspectives from which to view the situation and included:

- Perform additional work only if the outcome will provide information that is qualitatively different (e.g, not another attitudinal survey) from that already available.
- Use accepted theories of stress and review the data with the objective of supporting the theories.
- Conduct no new studies because the available information is sufficient to suggest that conducting new studies and postponing restart may only prolong the time to conflict resolution among the individuals in the community.

For those comments pertinent to the first group, the specific suggestions for data gathering and analysis were varied and included reanalysis of data already analyzed, analysis of data collected but not examined, and collection and analysis of raw data. In the realm of reanalysis, the essential idea was to evaluate collectively all of the TMI data now available to all of the investigators and organizations that have been studying the population in the TMI environs, with the objectives of attempting to:

- identify clusters of vulnerable individuals (e.g., those who exhibited high stress levels) for the purpose of further followup study;

- systematically correlate interstudy consistencies and inconsistencies; and

- discern any as yet unsubstantiated associations (e.g., level of distrust or suspicion of authorities with extent of stress response).

It was generally felt that with sufficient resources, this reanalysis could be completed within one month.

Given a longer period of time (i.e., up to 6 months) there were several suggested activities that essentially involved evaluation of as yet unanalyzed TMI data and gathering of new TMI data. The unanalyzed data focus on the TMI workers and on mothers in the TMI area and, as such, will be useful only for making observations about these groups and not for comparing them with other unassessed groups (e.g., fathers in the TMI area). However, there was an attempt made in the interviewing of these people to determine their response to restart of TMI-1. This information clearly would be most pertinent to the question of psychological stress associated with restart of TMI-1 and would add considerably to the data available on this issue.

The suggestions concerning new data collection were directed toward:

- collecting baseline data for future comparison with data collected during and after restart for use in evaluating the psychological stress effects of restart,

- collecting baseline data to identify the most appropriate methods of intervention and to assess any intervention methods ultimately employed,

- continued monitoring of existing study and control populations in an attempt to identify those individuals who may be just now emerging as chronic disabled,

- attempting to establish psychological/physiological correlates for use in identifying and analyzing high risk groups (e.g., further study of self-selected individuals), and

- collecting data useful in analyzing the psychological stress impacts associated with a decision not to restart TMI-1 (e.g., loss of employment, increased electric rates).

Although it was generally felt that recent TMI-specific data were the most useful in making predictions of restart stress and caution was expressed in assuming the TMI population was analogous to any other, interest was expressed in conducting a focused review of the non-TMI literature concerning general crises, natural disasters and the chronic psychologically disabled (e.g. Viet Nam veterans, individuals exposed to Agent Orange, victims of the Coconut Grove fire, people who have experienced earthquakes and hurricanes). The objectives of the review would be to:

- discern characteristics of those individuals most vulnerable to chronic disabled stress responses,

- obtain estimates concerning the rates of chronic disabled, and

- identify outer limits in terms of percentages below which a prediction concerning the stress effects expected in the TMI population post-restart should fall.

2.7.2 Potential Benefit

When queried concerning the benefits to be gained from engaging in these additional activities, the participants suggested that confidence in their predictions would definitely increase both in statistical terms and in the broader, non-statistical sense. The extent of this gain in confidence is difficult to estimate until it

is known what new information emerges or what existing correlations are strengthened or weakened. To the extent that these activities assist in any way in more clearly identifying high risk groups, developing or targeting treatment programs and designing intervention techniques, the benefit to the community is considerable (e.g., health effects prevention professionals have an opportunity to be proactive rather than reactive, individuals have an opportunity to participate in mitigation of potentially adverse health responses). It was also noted that, although additional efforts would likely contribute to a general understanding of the problem and ways to approach it, there would still be many questions unanswered and issues not addressed (e.g., is the measurement of distress in an individual an indication of successful adaptation and coping or is it an indication of psychological ill health?).

2.7.3 Summary

When queried concerning needed additional research and analysis, the suggestions from the Workshop members for efforts to be undertaken included:

- Collectively reanalyze existing TMI data.
- Analyze recently collected TMI data that have not yet been evaluated.
- Gather and analyze new TMI data.
- Conduct a focused review of the existing non-TMI literature concerning general crises, natural disasters and chronic psychological disability.

It was generally felt that, although the extent of the benefit to be gained from these additional efforts was difficult to estimate, general understanding of the TMI population clearly would be enhanced. This understanding is critical to predictions of the impact on this population of any event and could be most important in selecting and monitoring any ameliorative measures employed should TMI-1 be restarted. In addition, it was felt that the ability of the expert community to predict, and/or suggest mitigating measures for, the effects in other populations of other similar events would be increased.

2.8 Ameliorative Actions

Although not specifically an agenda topic for this Workshop, the identification of actions for ameliorating potential psychological stress associated with a TMI-1 restart was felt by the participants to be useful and consistent with the prior discussions of ways to predict psychological stress responses. Stress responses may be linked to whatever measures might be put in place to ameliorate those responses.

The panel insisted on having the record show that although the listing of potential ameliorative actions presumed that TMI-1 would restart, the panel is not thereby implying an endorsement of the restart of TMI-1. At the same time, the panel noted that the preparation of this list of possible actions does not imply that TMI-1 restart could not proceed without some or all of them.

2.8.1 Purpose of Ameliorative Actions

The identification of ameliorative actions proceeds from the premise that such actions will, indeed, help the situation. One participant cautioned that some data suggest that educational activities of this sort can actually exacerbate stress levels for some people. With this qualifier in mind, the expert participants observed that the principal purpose of ameliorative actions would be to reduce stress through a combination of education, information access, and counseling. Treatment of stress requires redefinition of the stress and its causes in terms with which the stressed individual can deal; education serves this function well.

Suggested actions focused on lessening the psychological impact of a TMI-1 restart on the local community. The Workshop consciously avoided designing another study to impose on the TMI population although, as noted below, the participants did suggest that the ameliorative actions and their impact be monitored so that they can be evaluated for future use.

It was noted that ameliorative actions should be employed only to lessen psychological stress during a restart and not to deflect opposition to a restart, which may come from many legitimate sources. The selected actions should be those that the population itself might ask for.

Consistent with their principal purpose of stress reduction, ameliorative actions can also be integrated with plans for gathering data for analysis of the effectiveness of the various measures.

Opportunity to monitor the community and individual stress levels during any restart process should be planned for. However, there was a difference of opinion within the panel as to how this data gathering should proceed. One view held that applying different ameliorative actions to different communities within the TMI population would enable the relative effectiveness of alternative actions to be reliably measured. Others argued that such a controlled experiment would be unacceptable since it might lead to certain communities being deprived of the more effective ameliorative actions, assuming the more effective actions could be identified in advance of any measurement. It was generally agreed that ameliorative measures with proven effectiveness must be offered to all if offered to any; actions of doubtful worth may properly be restricted and differential results measured.

The monitoring and analysis of the responses to various ameliorative actions could lead to recommendations of the more effective actions for similar events should they occur in the future. The greater use of the media as a means for stress reduction should be a typical activity for monitoring.

Prior to a restart, data gathering and analysis should be directed toward identifying appropriate ameliorative actions to implement and toward determining the current level of distrust among the TMI population, a factor the experts agreed was of great importance.

2.8.2 Preconditions for Applying Ameliorative Actions

The participants observed that prior to the selection and implementation of ameliorative actions, attempts should be made to satisfy at least the following preconditions:

- The safety of TMI-1 should be convincingly assured; to do this may require the involvement of a broad spectrum of official expert opinion on the safety issue.
- The credibility of expert and/or public officials should be improved.
- A believable and concise case for the restart of TMI-1 should be made. Public officials should be forthright and direct regarding the reality of a startup, clearly informing the public of the institutional, economic, and technical considerations affecting a startup decision as well as the projected timing and procedures.
- The absence of any legal or procedural connection between the TMI-1 restart and any future operation of TMI-2 should be made unequivocally clear.

2.8.3 Guidelines, Procedures, and Approaches

Ameliorative actions suggested by the participants were presented in varying levels of detail. Suggestions ranged from broad guidelines for conducting an ameliorative action plan to specific mechanisms for interaction with the public.

Members of the Workshop suggested guidelines for an ameliorative action plan which included the following:

- To command public respect, a TMI-1 restart plan, at the time it is announced, should offer a definitive and prompt schedule of events, including all ameliorative activities.
- Ameliorative actions will be most effective if focused on educating the public as to what is to happen both technically and procedurally, including the real risks of accident and the potential consequences. One expert suggested that this

educational thrust be modeled after the successful efforts to reduce stress associated with impending surgery in which pre-surgery familiarity with the operating room and procedures has been found to lessen the psychological impact and improve the recovery process. Another participant cautioned that such educational efforts have the effect of exacerbating stress for some people (e.g., those highly stressed groups for whom education can undermine a "denial" coping mechanism).

- The psychological aspects of what is likely to happen should be directly confronted. The public's fear should be openly addressed, recognized as understandable, and mitigated by credible information flow.

- Every attempt should be made to ensure credibility in the pre-startup education process. For example, the condescending tone perceived by some when the nuclear engineering community is addressing the public should be avoided. Instead, a broad spectrum of expert opinion should be enlisted. (An effective example of the latter occurred during the krypton venting at TMI-2 where the NRC and utility officials, the media and authoritative scientific sources all supported the view that venting was needed and would not harm the population.)

Going beyond the general guidelines listed above, the expert participants' suggestions included a number of procedural recommendations, of which the major ones are summarized below:

- Public meetings are more likely to succeed if authorities work with many small, selected groups rather than one or two large community forums. Large forums are seen from experience to aggravate rather than mitigate stress.

- Information on the restart should emanate from a single authoritative source as opposed to the use of groups of community professionals (e.g., teachers, clergy, physicians) with ad hoc training to educate the rest of the community on the TMI-1 restart issue. In this way, it was felt that the interjection of personal views in the public education process could be minimized. On the other hand, some felt that community professional groups should be involved in the information dissemination process since they have well established and accepted contact with the community and may be called upon by the public to deal with the TMI issue.

- Attempts should be made to enlist the help of credible authoritative agencies such as the U.S. Public Health Service and the National Academy of Sciences, which to date have not played a significant role in educating the public on the issues of nuclear power and which do not have a vested interest in the restart.

- Educational efforts should concentrate on the more vulnerable or highly stressed subgroups, of which the major ones identified so far are:

  - women, particularly those who are pregnant or are mothers of young children; and

  - people who feel the greatest distrust for authorities in the nuclear power arena.

- An effective action program will have to be scheduled to accommodate the fact that stress is most likely to be the greatest during the week prior to restart and can be expected to decline steadily after a successful startup. In this connection, the participants observed that although a nuclear plant restart is several weeks in duration, the "event" will be marked by the beginning of the process. Educational effort and other ameliorative actions should continue after the restart event for as long as there is an apparent need for them (i.e., the public continues to particpate).

The Workshop sought to avoid suggesting specific tasks or approaches to be considered as part of an ameliorative action plan. Nevertheless, a few detailed suggestions did emerge from the discussion:

- As a vehicle for providing a single authoritative information source, several participants supported the concept of a continuous, interactive, television broadcast involving credible experts in the field. Interaction would be provided by a continuous phone-in, open-line format.

- Provision should be made for plant visits, specially tailored to the concerns of the TMI community, for interested citizens.

2.8.4 Summary

Assuming, but not necessarily recommending, a TMI-1 restart, the expert participants suggested ameliorative actions for minimizing any psychological stress response. It was noted that the central focus of such actions should be on a combination of education, information access and counseling. They should not serve to deflect legitimate opposition.

Prior to implementing ameliorative actions, the safety of TMI-1 should be convincingly assured, the case for TMI-1 restart should be soundly presented and attempts at restoring official credibility should be made. Successful ameliorative actions would then be guided by an emphasis on objective information exchange and on open confrontation of the sources of fear.

Further, the participants suggested that:

- large community forums be avoided;
- information flow from a single authoritative source, with community professional groups involved to the extent practical;
- other authoritative agencies such as the U.S. Public Health Service and the National Academy of Sciences be involved to help restore credibility;
- efforts be focused on vulnerable subgroups, such as mothers of young children; and,
- the scheduling of actions accommodate the peaking of stress approximately one week before the event and continue after the event for as long as needed.

Specifically, an effective implementing vehicle for ameliorating stress may be a continuous interactive television broadcast providing the people with access to credible nuclear experts.

3.0 POST-WORKSHOP OPINION PAPERS

3.1

COMMENT ON PSYCHOLOGICAL STRESS WORKSHOP

Robert R. Holt[1]
New York University

I appreciate the opportunity to submit the following reflections on the issues addressed at the recent workshop on psychological stress, held under the auspices of the MITRE Corporation, February 4 and 5, 1982.

Feasibility of prediction: General. The underlying problem was the need of the Nuclear Regulatory Commission to frame an appropriate response to the court order calling upon the NRC to decide whether or not to order a full-scale environmental impact statement for the restart of TMI-1 on the grounds of its possible adverse impact upon the psychological health and community well-being of people living in the affected region. Such a statement, like many another technology assessment, is predictive in character, being an attempt to figure on the basis of scientific data and theory what is likely to be the consequence of a contemplated technological move. In this case, there is the novel feature that the consequences are psychological, psychiatric, and sociological in nature, and the data and theories involved are almost exclusively those of the behavioral and medical sciences.

The first question that must be addressed, therefore, is the basic one: Is prediction possible in psychology? And if so, is it good enough to justify the cost of the requisite research? An unequivocally positive answer can be given: The actual record of predictions in the behavioral sciences is quite respectable, particularly when one recalls that prediction is difficult and imprecise in any science once we get outside the doors of the laboratory and try to say what will happen under real-life conditions. Even meteorologists occasionally stumble, despite their statistically excellent track record and the fact that they are dealing with an application of the most thoroughly established physical sciences. The behavioral sciences can point to a number of rather distinguished successes

1. Preparation of this paper was supported by a United States Public Health Service Research Career Award, Grant No. 5-K06-MH-12455, from the National Institute of Mental Health.

in a variety of realms.[2] We can predict to a useful degree by a cost-benefit criterion such diverse behavior as voting in political elections (with a probable error of about 2%), academic grades in college, the likelihood that prisoners will violate parole, and the economic behavior of consumers--their decisions to spend or save. That does not guarantee that every behavioral scientist will do a creditable job in attempts to predict any behavior, but it does at least serve to dismiss the claim by some ignorant or cynical critics that human behavior is intrinsically unpredictable.

Furthermore, the nature of the alternative must be borne in mind--the certainty that if no attempt is made to collect and process data in a scientific manner, the decision will be made anyway without the benefit of the most relevant facts and theories. Under such circumstances, decisions are likely to be influenced by political pressures and other extrinsic considerations, despite all the good will in the world on the part of the decision makers. Moreover, the conclusions of an environmental impact study could at most have advisory and not definitive influence. Granted the importance of the present issue, the conclusion seems inescapable that the decision should be made with scientific guidance and a maximum of relevant information.

Feasibility of a prediction study: Specific. It would be possible to do a meaningful and useful predictive impact study, for the following reasons. First, there was substantial consensus at the workshop that chronic psychological stress has produced a small but measurable and deleterious chronic impact upon psychological health in the Three Mile Island area. Second, it is possible to explain and understand those effects by means of a coherent psychological theory, which

---

2. I have reviewed relevant studies in my book Methods in clinical psychology. Vol. 2: Prediction and research. New York: Plenum, 1978. Much of the theoretical section below is based upon work done for my chapter, "Occupational stress," in L. Goldberger & S. Breznitz (eds.), Handbook of stress, New York: Macmillan Free Press, in press.

provides the specifications for a set of data needed to make predictions about further such effects that would be caused by restart. Third, the needed data do not presently exist, but can be obtained quite feasibly and not too expensively. The remainder of this communication will be devoted to sketching the theory, the design of a feasible study, and supporting details. I omit a summary of the available evidence in support of the first numbered assertion in this paragraph, because I believe that it is already available to MITRE and to the NRC staff.

Theory of effects of radiological stress on psychological health. No claim is being made that ionizing radiation itself has a direct impact upon psychological health, and no denial that effects could exist, either. The rationale to be presented does not depend upon the actual irradiation of anyone, only the threat thereof.

A theoretical understanding of the impairment of health from such causes as we are dealing with here may be expressed via the following schematic flow charts. First, consider a normal, healthy state of affairs when a person is confronted by danger (Fig. 1). The diagram says that perceived danger arouses a physiological alarm system, which sustains adaptive efforts, which lead to successful coping, which cause an increase in the sense of adequacy and effectiveness; the perception of success inhibits the adaptive efforts (no longer necessary), and the increased sense of adequacy helps inhibit physiological alarm. In addition to the indicated effects of successful adaptive efforts, by definition they also take the person out of danger, hence stop the continuous input to the system, which switches off.

Consider now the unsuccessful case (fig. 2). When the adaptive efforts fail (as by encountering a barrier that prevents either escape or successful counterattack) and the danger persists, input to the alarm system is continuous, and there is a secondary effect through the person's seeing his inability to be effective--he feels inadequate or helpless, which tends to inhibit adaptive ef-

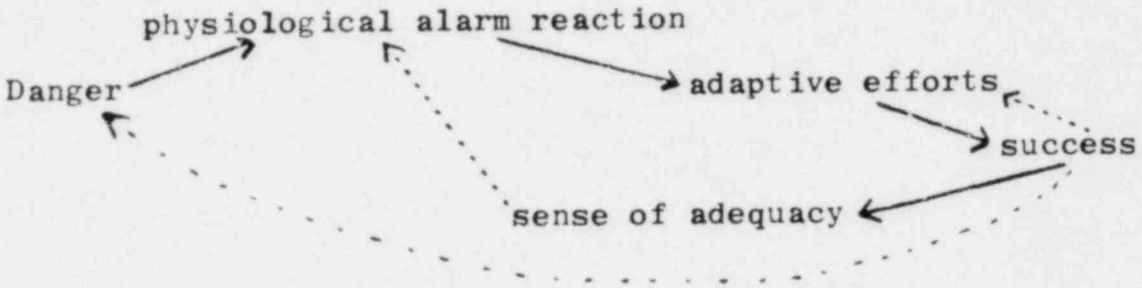


Figure 1. Diagram of normal, adaptive response to experienced danger

(Note: In this and the following diagrams, solid lines indicate a stimulative or enhancing effect, dotted lines an inhibitory or switch-off effect.)

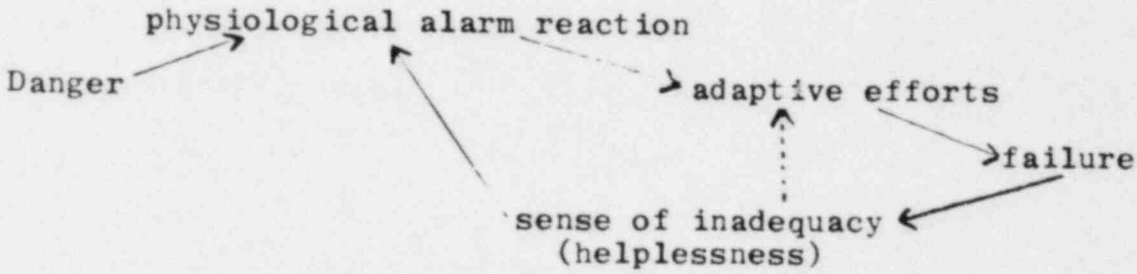


Figure 2. Diagram of unsuccessful response to experienced danger

forts and to have a multiplier effect on physiological alarm (positive feedback loop). That then brings into play the pathological system diagrammed in Fig. 3.

Fig. 3 tells us that when physiological alarm reactions become chronic, from continuous instigating inputs (Fig.2), they produce a set of what are known as physiological strains (e.g., hypersecretion of various endocrine glands and of the stomach, hypertension, overreaction of the reticular activating system, release of histamine, etc.), which produce such stress symptoms (of Selye's General Adaptation Syndrome) as tremulousness, gastritis, headaches, insomnia, hives, etc. These symptoms in turn interfere with normal adaptive behavior. Meanwhile, the chronic sense of helplessness and inadequacy produces--in interaction with some of the physiological strains--a set of psychological symptoms including anxiety, depression, and anomie (alienation, loss of morale), which also interfere with normal adaptive behavior. Unable to cope effectively with his problems, the person feels even more inadequate and helpless. This positive feedback loop from impaired adaptiveness to the sense of helplessness and back again constitutes a "vicious circle" that tends to amplify the effect of the chronic alarm state, so that the condition has a tendency to become worse. (At the same time, a number of counterbalancing factors tend to diminish the pathogenicity of the vicious circle, notably a belief that the danger is diminishing.) Note also the indication that the sense of helplessness makes some contribution to stress symptoms and directly interferes with adaptive coping efforts. If other stresses are present, they also contribute to the physiological strains.

The region near the right side of Fig. 3 indicated by dashed vertical lines indicates a set of moderating variables,[3] some of which ("weakeners") serve to exacerbate, others ("strengtheners") to ameliorate or counteract the pathogenic

---

3. In the interests of keeping the diagram relatively simple, I have omitted a good many other moderating variables that have been postulated (notably, defenses, coping devices or strategies, and cognitive styles). There is evidence that some of them are important in determining the "choice of illness" or symptom specificity, which I am neglecting here.

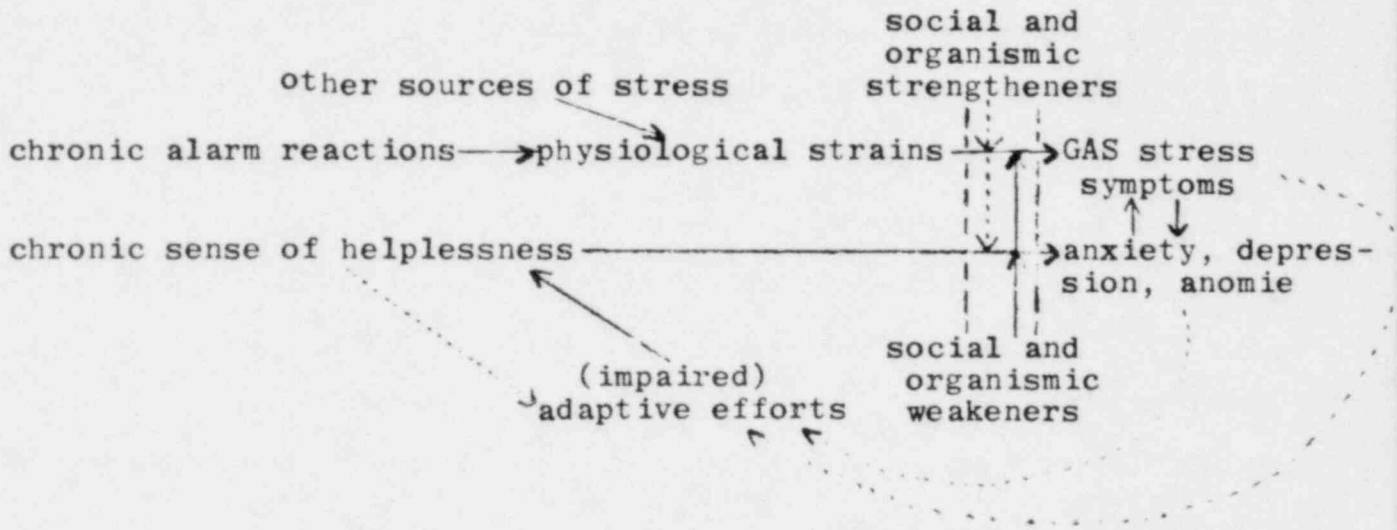


Figure 3. Diagram of chronic impairment of health

process. More is known about weakeners than strengtheners; the former include physiological conditions and developmental stages (e.g., physical illness, malnutrition, mental deficiency, pregnancy, infancy and childhood, menopause, old age) and sociopsychological states (e.g., unemployment, poverty, institutionalization, marital friction, vocational dissatisfaction). A special subclass is prior exposure to the same danger (e.g., people who evacuated at the time of the accident and/or the krypton venting). The principal strengthener identified in stressresearch is social support networks: the more a person feels sustained and supported by family, friends, helpful coworkers and supervisors, the more resiliently he tends to respond to otherwise stressful conditions. A further important variable, the degree to which the person trusts and believes experts and authorities (sources of information concerning the danter), can be conceived as operating as one of these moderating variables.

A useful way to look upon the moderator variables is that the list of weakeners constitutes a set of hypotheses about subpopulations at risk--those who may be expected, in light of available research evidence, to be most susceptible to stress and other deleterious effects of a given environmental impact (such as the proposed restart of TMI-1). Retrospective or secondary analysis of data from such studies as those of Houts, Bromet, Kasl, Vyner, and Goldsteen should be used to test some of these hypotheses and to identify other groups at risk to develop adverse health impacts from reactor-induced threat.

At this point, the above theory may be restated in the form of a general and a specific proposition.

1. People who feel chronically endangered and helpless to avoid peril eventually suffer adverse effects upon their health,[4] expressed in an increase

---

4. Though two classes of symptoms are distinguished here, I do not try to subdivide the concept of health, which is by definition a characterization of the whole person. A person suffering from largely physiological stress symptoms can hardly be said to be in a good state of psychological health. It is also not meaningful to try to classify certain symptoms (e.g., nausea, insomnia) as either psychological or physiological: they are organismic.

in both psychological (mental, emotional) and physiological (physical, bodily) symptoms, which will be especially severe in identifiable groups at risk.

2. Such a pathogenic state will come about in persons in the vicinity of an operating nuclear plant, if these persons believe that they are endangered by the nuclear plant and if they feel helpless to take effective action to increase their safety.

Note that in statement 2, "vicinity" must be subjectively defined: a person is in the vicinity if s/he believes that s/he is close enough to be harmed, either by routine operations or by an accident. Evacuation studies showed that some persons 50 or more miles from TMI felt themselves enough endangered by the accident to leave their homes and travel considerable distances for several days to escape; hence, adopting an arbitrary though convenient physical definition of "vicinity" will result in underestimating deleterious impacts of a restart upon health.

Note also that the fear (feeling of endangerment) may be to various degrees rational, based upon a correct understanding of the nature of ionizing radiation and its biological effects and of the structure and functioning of nuclear power plants, or irrational and ill-informed; that is largely irrelevant. Educational efforts would alleviate the irrational components, to the extent that they were credible, but valid information about the nature of ionizing radiation and its biological effects or about the actual structure and functioning of TMI-1 and the range of accidents that are possible there would probably increase fear even though it was presented as part of an effort at amelioration, counter to the beliefs and hopes of the industry.[5] As Slovic and his colleagues have demonstrated, nuclear power is considered an especially dread source of danger because of its unusual characteristics: Ionizing radiation is imperceptible, hence the citizen

---

5. And invalid information would cause a further increase in distrust, seriously undermining the effectiveness of emergency measures should they be needed.

is dependent upon experts and authorities for all relevant information, and because of their past performance (especially during and after the 1979 accident) s/he often distrusts official reassurances; and nuclear plants can have catastrophic accidents, with disastrous consequences. The public is much less reassurred than are those who work for the utility or the NRC by figures on the low probability of such accidents; indeed, the public believes that less is known about the dangers of nuclear power and with less certainty than experts claim.

A final comment on the above theory: It is intended to account for chronic impairment of health, not acute reactions such as those to the 1979 accident, or the venting of krypton. If there were a restart of TMI-1, one might expect a transient anticipatory flare-up of anxiety, norepenephrine secretion, and other such effects as those reported by Baum et al. in their venting study; but I am neglecting such effects here. Likewise, I consider of negligible importance the possibility of a phobic reaction focussed on the event of restart itself, which seems to have engaged so much of Dr. Dupont's attention. As to the possibly stressful effects of a decision not to restart, it seems safe to assume that they would be confined to a very small group of workers who would lose their jobs; my expectation is that stockholders would experience stress primarily to their portfolios.

What I have described as a theory here could also be viewed as a series of testable hypotheses, which can and should be tested. To the extent that it is valid, the theory can then be used to predict the effect of the restart, using freshly gathered data.

Needed research. What we need, therefore, is a two-tier or dual study: first, the basic hypotheses of the theory need to be tested; in part, that can be done by means of a secondary analysis of existing data, but in part it will require the gathering of data to test the postulated relationship between chronic health effects and certain beliefs about which no investigators have reported inquiring, in any research I have read. Second, in order to predict the impact of a restart on psychological health, it will be necessary to obtain new, up-to-date data in the entire affected region.

The basic kind of data needed from reanalyses of existing data bases is simple and straightforward: cross-tabulation of all items of belief and attitude against measures of health effects, to yield incidence rates for symptoms by groups of people holding different beliefs. Thus, for example, suppose an investigator asked, "How dangerous do you feel that TMI is to you today--extremely dangerous, dangerous, slightly dangerous, not dangerous at all?" In the same survey, assume that people were also asked how often they had headaches: often, occasionally, or never. The cross-tabulation should be reported in a table of four columns (degrees of danger) and three rows (frequency of headaches), so that one can compare percentages of people reporting many, few, or no headaches among those who admit to various degrees of endangerment. Such cross-tabulations should be done for homogeneous groups separately, whenever they are large enough. (E.g., as Bromet analyzed in this way the data for mothers and for plant workers.) In order to minimize the likelihood of contaminating the chronic with acute effects, these analyses should be done only with data taken at least six months after the accident (i e., from mid-October 1979 to date).

The basic method of prediction would be, then, to follow this model: Suppose that in a certain sector of the population 15% of those who reported that TMI was "extremely dangerous" reported having headaches "often." The predictive study would ask a new sample of that same subpopulation, "How dangerous do you

feel TMI would be to you if unit 1 is restarted--extremely dangerous...not dangerous at all?" For those who replied, "extremely dangerous," the prediction would be that 15% of them would develop frequent headaches. From a knowledge of sampling rates and the size of the target population, it would be possible to assemble a final total prediction of the number of persons who would develop chronic impairment of psychological health.

There are of course many more details to be worked out for the concrete planning of the project. I trust, however, that the above is enough to indicate (a) that the proposed predictive method is logical and feasible, (b) that no such study has been done to date, and (c) that some use could be made of existing data, but that further data are indispensable. Note also that if TMI-1 is in fact restarted, the design makes it simple to collect the data needed to validate the predictions. (Under those conditions, it would be useful to have a control group from an area where people do not consider themselves endangered by TMI. It is rather striking that in the venting research by Baum et al., appreciable numbers of people in the control community of Frederick, MD did report feeling threatened by TMI, thereby not constituting as sensitive a control group as would have been desirable.)

For the predictive study, the respondents should consist of a basic probability sample drawn from the area 5 miles or less from the plant, 5 to 10 miles, 10 to 15, 15 to 20, 20 to 25, and 40 to 55 miles from the plant, sampling at lower rates in each larger ring. This general sample should be supplemented by special samples of at-risk subgroups: e.g., pregnant women and mothers of infants and toddlers, unemployed breadwinners, poor minority group members, et al. A control group from a distant but demographically comparable area would be highly desirable but not necessary.

Questions to be asked[6] should first gather basic data concerning respondents' (Rs') information and beliefs concerning TMI-1 and nuclear power. Those who are unaware of the plant cannot feel threatened by it; likewise those who know of no dangers posed by nuclear plants. The nature and extent of any threat or danger R believes that TMI-1 would entail to himself or to those he loves or is responsible for if restarted; beliefs about the effects of ionizing radiation upon health and one's progeny; beliefs about past exposure to radiation and degree of damage thereby; beliefs concerning the detectability of ionizing radiation by the senses, and how one does ascertain that one is or may be exposed to appreciable doses, what to do about it, and when the danger is over; beliefs about the persons who have the technical knowledge and instruments to monitor radiological danger and persons who transmit such information to the public, their motivation (are they seen as disinterested or biased by the profit motive?), their competence, and their credibility; beliefs about the amount and dangerousness of radiation (or radionuclides) emitted in "routine operations"; beliefs about possible accidents--how serious they might be, and how likely, and how far R's apprehension about consequences is mitigated by knowledge of their (low) probability; knowledge of and beliefs about emergency planning and readiness, including R's own plans if any about what to do in case of another serious accident; beliefs about other ways and the total degree to which R could protect self and others about whom he cares; beliefs concerning any other harms, and concerning all benefits, to be expected from restart; beliefs concerning dangers or bad consequences of <u>not</u> restarting; R's overall feeling about the desirability of restart. With respect to many above questions, it would be desirable to ascertain the degree of uncertainty R feels about the answer.

---

6. The proposed secondary analysis of existing data bases would be very helpful to the framing of questions. To some extent, alternative ways of wording similar inquiries may show different ability to predict symptoms.

To ascertain R's possible membership in at-risk groups, questions concerning various demographic variables (e.g., occupation, employment, age, marital status, number of dependents or persons for whom R feels personally responsible), state of health--general, and degree to which R currently experiences stress symptoms (those assessed by Houts, by Bromet, and by the demoralization scale), history of past hospitalizations and serious illnesses, general level of life satisfaction, Rahe life-event score and other recent stressful experiences, general level of alienation vs. trust and faith in basic institutions. What did R do and experience at time of TMI-2 accident and Kr venting--evacuate? How does R feel now about own response at those times? What has R done on other occasions to indicate degree of concern about possible adverse effects of radiation? What is the nature and extent of R's social support network? What is R's general level of self-esteem and feeling of competence vs. helplessness?

The necessary data could be gathered by an independent survey research organization (I would recommend Yankelovich, Skelly, & White, Inc., of New York City, which has the capability to do in-depth interviewing anywhere in the country, and all of the other needed technical resources--e.g., drawing the sample).

Since the two-stage predictive study outlined is quite feasible at reasonable cost, and could be completed within a few months, and since it would greatly enhance the NRC's ability to estimate the probable environmental impact of restart, I strongly urge that such a project be undertaken. I would be glad to consult with its directors or to supply backup data, references, etc., supporting various statements made here.

3.2

Ronald W. Perry

Statement

The purpose of this statement is to concisely summarize my views regarding the objectives addressed during the workshop. I propose to accomplish this by posing, and then answering, a series of questions.

Question 1. There is an existing literature describing psychological consequences of exposure to stressful events, where the event is the impact or threatened impact of a natural disaster. What do these studies tell us about peoples response to massive stressful events?

The disaster literature documents the idea that citizens rarely--except under specific conditions not usually created in natural or technological disasters--panic or exhibit severely maladaptive behavior in connection with the disaster event (Quarantelli and Dynes, 1972; Taylor, 1977; Quarantelli and Dynes, 1977). Indeed, during the immediate post-impact period a few investigators have reported that some "unstable" individuals (particularly those diagnosed as senile) have briefly exhibited "stable" behavior--usually task-oriented helping actions (cf. Perry and Lindell, 1978:111).

With regard to negative psychological consequences, there is a general consensus among investigators that there does appear to be an identifiable "disaster syndrome"--a dazed state common in the immediate post-impact period of disasters characterized by high levels of physical destruction. This is usually an immediate reaction which passes quickly. A variety of other symptoms have been documented which also appear to be transient: bed wetting, general ("free floating") anxiety, depression, difficulty in sleeping[1]. Goldstein (1960) and Wilson (1962) point out that "normal" disaster reactions clear up quickly;

Quarantelli and Dynes (1970:68) indicate that "only in a minority of cases do victims exhibit a shock reaction". The full course of the "disaster syndrome", when it does occur, may run only a couple of weeks (Wallace, 1956; Wallace, 1957:24; Killian, 1954:68).

The literature also shows that longer term reactions are equally infrequent in occurance. Studies indicate that in the post-emergency period disasters show little or no effect upon citizens' patterns of interacting with family members (Drabek et al., 1975; Erickson et al., 1976) or on other primary group linkages (Drabek and Key, 1976). Furthermore, disasters are not correlated any appreciable incidence of psychiatric disorder (Gilbert, 1958; Bates et al., 1963; Mileti et al., 1975; Quarantelli, 1980). Indeed, a recent controlled study covering a period of three years found no significant long-term effects of experiencing a natural disaster on the health self-perceptions of victims (Sterling et al., 1977).

There are three general exceptions to the rule that disasters are not associated with observed negative psychological consequences among those exposed. First, when disaster impact causes high levels of physical destruction and thereby affects the majority of people in a given social system, there appears to be greater psychological disruption among some victims (Fritz, 1957; Wallace, 1957). In such cases shock reactions appear to occur in some citizens, but the total proportion of people

---

[1]For discussions of transient symptoms see: Tyhurst, 1957a, 1957b; Menninger, 1952; Moore, 1958a, 1958b; Moore and Friedsam, 1959; Moore et al., 1963; Lifton and Olson, 1976; Logue et al., 1981; Barton, 1969:80).

affected seems to remain small. Second, some people exhibit grief reactions in the post-impact period which may persist over time (cf. Lindemann, 1944; Bugen, 1977). Such reactions are typically observed where victims are exposed to dead or severely injured individuals, and particularly when relatives of victims are involved (Fritz and Marks, 1954). A third class of people who seem to exhibit negative psychological consequences after a disaster are people who were exhibiting symptoms before the disaster, or those with a history of coping difficulties. Support for this proposition dates back to Kardiner (1959) and has been succinctly summarized by Hudgens (1974:120):

> ". . . investigators have demonstrated a causal connection between stressful life events and subsequent worsening of conditions already underway, . . . between bereavement and depressions . . . . It does not seem to me that investigators have yet convincingly demonstrated that life stress can cause madness in a person previously of sound mind."

In summary, the disaster literature indicates that following disaster impact most people in a community exposed to the disaster do not experience negative psychological consequences. In a very small proportion of people persistent symptoms may appear, but usually under the special circumstances noted above.

Question 2. Are natural disasters comparable to the case of nuclear power plant emergencies or other technological threats potentially involving radiation?

Disasters are usually thought of as catastrophic events, frequently asociated with the forces of nature: earthquakes, tornadoes, hurricanes, etc. Yet other events, such as explosions, chemical spills or industrial accidents, are also described as disasters. In establishing parameters for the social scientific study of disaster, Charles Fritz (1961:655) has advanced a definition which concentrates on important distinguishing features of disaster events. He suggests that a disaster is any event:

> . . . concentrated in time and space, in which a society or a relatively self-sufficient subdivision of society, undergoes severe danger and incurs such losses to its members and physical appurtenances that the social structure is disrupted and the fulfillment of all or some of the essential functions of the society is prevented.

This classic definition stresses that disasters occur at a definite time and place and that they disrupt social intercourse for some period of time. Allen Barton (1969:38) proposes a similar definition, but chooses to focus upon social systems, arguing that disasters exist "when many members of a social system fail to receive expected conditions of life from the system". Both Fritz and Barton agree that any event which results in a significant change in inputs or outputs for a given social system is accurately characterized as a disaster. The important point to be derived from inspecting these definitions is that volcanoes, hurricanes, floods, chemical spills, explosions, or nuclear power plant accidents all fit equally well into either definition. Hence, at this level of abstraction, both nuclear and nonnuclear disasters may be treated under the same conceptual rubric.

Given that nuclear and nonnuclear disasters may be subsumed under the same definitional umbrella, one can further specify the links between the two classes of events by comparing them in relation to known disaster characteristics in general. That is, one can specify how nuclear and nonnuclear disasters compare relative to important defining characteristics of disaster events.

There has been some discussion of how nuclear and nonnuclear disasters differ in the early literature on human response to natural disasters. Most of this work was done at the Ohio State University Disaster Research Center between 1963 and 1972 and focused upon the

problem of assessing the implications of studies of natural disaster for the problem of nuclear attack (Kreps, 1979). One study, conducted by Anderson (1969) examines the functioning of civil defense offices in natural disasters and applies his findings to the nuclear attack environment. In developing his analysis Anderson argued that in spite of various differences between nuclear and nonnuclear disasters:

> . . . [these differences] can be visualized as primarily ones of degree. With the exception of the specific form of secondary threat, i.e. radiation, and the probability that a wider geographic area will be involved, a nuclear [disaster] would not create essentially different problems for community response (1969:55).

Therefore, Anderson began laying the basis of a scheme to compare nuclear with natural disasters by examining two important distinguishing features of disasters: the form of secondary impacts and the scope of impact.

Allen Barton (1969) advanced a classification scheme for disasters which builds upon the two distinguishing features used by Anderson. In his attempt to characterize the nature of social system stress Barton chose four basic dimensions: scope of impact, speed of onset, duration of impact, and social preparedness (1969:40-47). Scope of impact is a geographic reference categorizing impact as involving either a small area or only a few people (narrow impact), or as encompassing a large area or number of people (widespread impact). Speed of onset refers to the suddenness of impact or to the time period between detection of a hazard and its ipact on the social system. This dimension is usually classified as either sudden or gradual. Duration of the impact itself refers to the time that elapses between initial onset of impact and the point at which it subsides. This can be a few minute (short) in the case of a tornado, or several hours (long) in the case of some riverine floods. Finally,

social preparedness is used in the context of possible forewarning to indicate whether or not the current state of technology permits authorities to anticipate or predict a thratened disaster impact.

In addition to the dimensions discussed by Barton, we will also retain Anderson's concept of secondary impacts in our scheme. Virtually all hazards, whether nuclear or nonnuclear, entail some secondary impacts; in some cases the secondary impact is even more devastating than the initial or primary impact. Riverine floods tend to deposit silt and debris over inundated areas, earthquakes involve aftershocks and often result in urban fires, tropical cyclones leave great physical destruction, often creating public health risks. Nuclear power plant accidents potentially involve radioactive atmospheric releases thereby producing a possibly lingering secondary impact in the form of residual radiation.

By assembling lists of distinguishing characteristics such as those elaborated above, one can classify a range of disaster agents and be alerted to important distinctions among them.

Thus, it can be argued that one can appropriately examine a variety of disasters within the same conceptual and analytic framework. The same basic definition subsumes all of the events, and they may be described using a single scheme for defining characteristics of disasters. Hence, a careful examination of the problem reveals no significant conceptual reason for treating nuclear and nonnuclear hazards as fundamentally different such that they must be separated and examined using different frameworks in social scientific analysis.

Unique Aspects of Disaster Events

The preceding discussion was meant to demonstrate that logical and appropriate comparisons can be made among nuclear and nonnuclear threats; analytically, in terms of the present state of disaster research, there is no justification for isolating nuclear disasters in a class by themselves. This is not to say, however, that all hazards--whether nuclear or nonnuclear--do not involve some unique characteristics.

In making comparisons, one must review and examine the implications of unique hazard characteristics for the human response variables of interest. The following paragraphs briefly highlight several unique aspects of the nuclear hazard by noting specific qualifiers.

As a disaster event, the most unique aspect of a nuclear power plant accident is that a nuclear component is involved. Thus, some attention is necessary because, in terms of the way people perceive the situation, such circumstances are different from those which accompany other disaster agents. Research indicates that some of the public views nuclear energy, and most applications of it, as a particularly threatening hazard with the potential for extraordinarily long-term negative effects. Of course, the idea that people have a different "mind set" for nuclear disasters certainly does not preclude comparisons with nonnuclear disasters. Instead it only requires that this dimension be acknowledged and that the necessary qualifications be made when such perceptual differences may have some bearing upon human performance.

Two aspects of this dimension should be mentioned here: risk perception and experience. The agent of threat to the human population in a nuclear power plant accident is nuclear radiation. In contemporary

American society, this agent is a high fear-generating mechanism regarding which the public at large is poorly informed (Rankin et al., 1978). Furthermore, surveys indicate that much of the information that the public does hold about nuclear power plants is technically incorrect (Earle, 1981). This situation produces an environment where some people potentially have exaggerated conceptions of the destructive potential of an accident, while others may believe that negative consequences are of less concern. Also, there is widespread disagreement on what constitutes a source of acceptable ("accurate") information about nuclear hazards, particularly power plants (Martin, 1980). Thus, public perception of danger associated with nuclear power plants is highly variable, and there are few sources of information perceived to be acceptable which might serve to promote a more homogeneous definition of threat. That is, through selective choice of information, individuals with extreme attitudes, whether exaggerating or minimizing risks, can locate sources which reinforce their point of view. Such circumstances tend to exacerbate the problems associated with emergency planning and response.

A second aspect of nuclear disasters is that most citizens lack a reference point in their experience for such events. Only one reactor accident involving potential threat to offsite populations has occurred in the United States, and this involved an area of comparatively small size around Harrisburg, Pennsylvania. While the media coverage was extensive, the majority of the population has at best only vicariously experienced the power plant accident. Consequently, unlike the situation which prevails with natural disasters, one cannot expect people's "prior experience" with nuclear disasters to help them arrive at a definition of threat associated with a given nuclear disaster.

In closing this discussion of the unique aspects of hazards, it is important to point out that, from the public's point of view, volcanoes share some of the emergency response problems associated with nuclear power plant accidents. Volcanic eruptions are not common, particularly in the continental United States, and public experience with them is almost nil. Furthermore, public knowledge of the risks associated with volcanoes is limited and sometimes technically inaccurate (Perry et al., 1980). In the case of volcanoes, however, there is an identifiable body of publicly accepted sources of information about the hazard. Thus, there is an available source of threat relevant data which the public may use in devising or arriving at situational definitions of threat.

Finally, the purpose of this discussion has been to document special aspects of hazards which may be helpful in interpreting human response data. As it was pointed out, the simple presence of some unique characteristics does not justify separating the analysis of nuclear and nonnuclear disasters. Instead, such distinguishing features should be acknowledged and treated as factors deserving special attention in the context of comparing human response to nuclear and natural disasters.

Question 3. What do the specific data on public response to the accident at TMI-Unit 2 tell us about psychological consequences?

Some of the studies discussed during the workshop allow us to consider the impact on the population as a whole. The data presented by Houts are based upon several surveys of persons living within five miles of TMI (plus a control group living 41-55 miles away). Houts and Goldhaber (1981) measured two classes of symptoms among those living within five miles of TMI. Behavioral symptoms were measured by asking: "Do/Did you have one or more of the following symptoms in the past two

weeks: lack of appetite, overeating, sleeplessness, shakes, trouble thinking, irritability, or anger?" (answer yes or no). Somatic symptoms used the question: "Do/Did you have any one or more of the following symptoms in the past two weeks: stomachaches, headaches, diarrhea, frequent urination, rash, abdominal pain, sweating spells?" (answer yes or no).

It should be pointed out that these operationalizations of distress are exceptionally sensitive measures which would pick up the widest possible range of possible discomfort, down to very low levels (cf. Perry and Lindell, 1978:107). A partial summary of the Houts and Goldhaber data (1981:160) are shown below.

Stress Proportions Among Respondents Living Within 5 Miles of TMI

Survey Time	Proportion Reporting Behavioral Symptoms (1)	Proportion Reporting Somatic Symptoms (2)	Proportion Who Attribute Symptoms to TMI (3)	Proportion of Behavioral Symptoms Attributed to TMI (1) x (3)	Proportion of Somatic Symptoms Attributed to TMI (2) x (3)
Jan/80	.40	.51	.25	.10	.13
Oct/80	.40	.40	.27	.11	.11

These data show that in the aggregate very few nearby citizens--about 11%--report feeling any negative symptoms which they attribute to the accident at TMI. In interpreting these findings one must remember that: (1) these are citizen attributions, not necessarily diagnosed disorders related to TMI; and (2) the measures of symptoms are very sensitive and picked up almost any discomfort. Considering these qualifications, the figures presented in the last two columns of the above table are probably an over-estimate.

The data on negative psychological consequences for people living near TMI agree with the data on natural disasters generally: most of the exposed population experiences no negative effects. Even with very sensitive measures, we find only 11% of the respondents who report symptoms which they believe might be related to TMI. The data on unobtrusive measures of stress (alcohol consumption, etc.) generated by Mileti, Hartsough and Madson (1981) buttress the above interpretation. These researchers found that while some indirect stress measures, particularly alcohol consumption, showed increases shortly after the 1979 incident, there was a tendancy to return to baseline and stay there. Also, although full information was not available to workshop members, studies of specific subsamples--pregnant women, women with children, TMI plant employees--where one might expect to find higher stress levels apparently show only very small proportions of these special groups who were experiencing prolonged stress.

Question 4. What do the findings discussed during the workshop allow one to say about the likely psychological consequences of restarting TMI-unit one?

In answering this question, a social scientist needs to consider at least two broad categories of psychological stress: (1) that which produces visible symptoms of a maladaptive nature in citizens and interferes with their ability to function in daily living, and (2) that which produces either no symptoms or symptoms which do not seem to affect the individual's ability to function. I will address the former class first.

Our review of studies of the accident at TMI-unit two tells us that, as we have found in studies of other disasters, only a very small proportion of the people exposed report any stress which they still

attribute to TMI. At present neither TMI-unit one nor unit two is operating. If unit one is restarted, will a significant proportion of nearby citizens experience psychological stress and manifest debilitating symptoms? The answer is no. There is no social scientific evidence in the specific studies of the TMI area or in the general literature on life event stress which even remotely suggests otherwise.

Even if one assumes a series of "worst case" scenarios, which hardly constitutes a reasonable social scientific approach, it is impossible to conclude that restarting TMI-one would produce negative psychological effects among any but a very small proportion of the nearby population. At worst, one might make the following succession of claims:

(1) Assume that nearby citizens would equate restarting of TMI-unit one with the accident at TMI-unit two.

(2) Assume that the 11% of people who attribute their self diagnosed somatic and behavioral symptoms to TMI are correct.

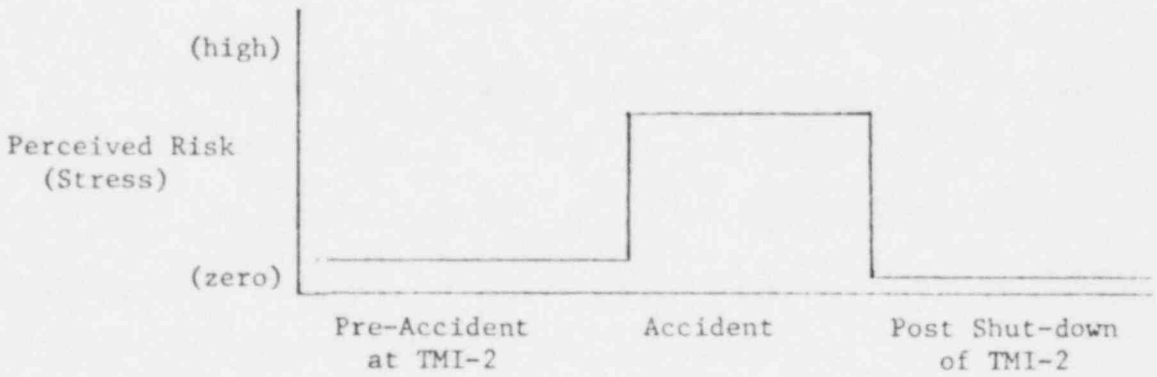
(3) Even though the symptoms described by the 11% apparently represent low levels of discomfort--rather than symptoms which prevent them from operating on a day-to-day basis, or for which they would require professional care, or for which they would require institutionalization--assume this state does constitute some degree of psychological stress.

(4) We could guess then, if these assumptions are correct, that some proportion of the people who are having trouble now will continue to have trouble after restart.

One should remember, however, that the assumptions listed above are highly unlikely to be completely true. Even under these circumstances, one finds that a very small proportion of the population might continue to experience some discomfort not of a debilitating nature. The idea here is that it would be unreasonable, even where speculating about worst cases, to expect that a greater proportion of people would experience more severe stress in relation to starting TMI-one, than reported mild stress in connection with the accident at unit two.

The second class of consequences apparently stemming from psychological stress is somewhat less straightforward to deal with. Indeed, there is some question about how to conceptually deal with apparent stress which generates no symptoms; behavioral sociologists and psychologists have argued that without the presence of some troublesome symptom, there is no stress. Stress which generates symptoms which do not interfere with the individual's functioning (i.e., that she/he effectively copes with) is also difficult to classify. Here we are dealing with "symptoms" which are not functionally debilitating, but that would probably be reported on an epidemiological survey.

Studies of natural disasters suggest that the extent to which an individual perceives that the hazard constitutes some level of risk to her/his health and safety is probably correlated with the "type" of psychological stress being discussed here. Thus, one can graph an approximate pattern of such stress relative to TMI as below.



The idea here is that stress was initially stable at some baseline (presumably above zero), was elevated during the accident period, and dropped to approximately zero during the period that both reactors have been shut down. (The last period is described as "approximately zero" because of the possibility that some people may believe that they were exposed to radiation during the accident and may therefore be in danger of exhibiting latent effects. The thrust of the graph is to represent perceptions in the aggregate, however, and special subpopulations.)

Based upon this reasoning, one can advance three hypotheses regarding stress which would be generated as a function of restarting TMI-unit one:

I. Maximum response hypothesis: After restart stress levels (perceived risk) would return to the same level as during the accident and continue there indefinitely.

II. Minimum response hypothesis: After restart stress levels (perceived risk) would return to approximately pre-accident level (baseline) and remain there indefinitely.

III. Accommodation hypothesis: After restart there would be a level of perceived risk above baseline but below accident period levels, which would decrease over time to approximately baseline.

Based upon the literature for natural disasters, one would predict that the accommodation hypothesis would best describe the response to restart.

This final discussion raises questions about the extent to which NRC, the government, or private industry should intervene in citizens' lives. We are talking about stress which doesn't seem to be manifest in severe maladaptive behaviors, and implying that some kind of "mitigation activities" may be necessary. It seems appropriate--as is the case with natural disasters--to provide citizens with available information about environmental hazards and attempt to protect them from serious negative consequences. In the case of stress which doesn't seem to produce such

serious consequences, both the role of government and the utility of any measures which might be undertaken seem more open to question. The act of living in a society might be described as the process of learning to cope with a series of stressors. It seems both inappropriate and ill advised for social scientists to argue that some federal agency should attempt to "remove" this type of stress. At best the ability of social and behavioral scientists to do this is doubtful. At worst, one risks creating more severe coping difficulties for the citizens involved than they would already experience in connection with the stressor.

References

Anderson, William A., 1969. Local Civil Defense in Natural Disaster. Columbus, Ohio: Ohio State University Disaster Research Center.

Barton, Allen, 1969. Communities in Disaster. New York: Basic Books.

Bates, Fredrick, Charles Fogleman, Vernon Parentin, R. H. Pittman and G. S. Tracy, 1963. The Social and Psychological Consequences of Natural Disaster. Washington, D.C.: National Academy of Sciences, National Academy of Sciences, National Research Council.

Bugen, Larry, 1977. Human Grief. American Journal of Orthopsychiatry 47:196-206.

Drabek, Thomas, William Key, Pat Erickson, and Juanita Crowe, 1975. The Impact of Disaster on Kin Relationships. Journal of Marriage and the Family 37:481-494.

Drabek, Thomas and W. H. Key, 1976. The Impact of Disaster on Primary Group Linkages. Mass Emergencies 1:89-105.

Earle, Timothy C., 1981. Public Perception of Industrial Risks. Seattle, Washington: Battelle Human Affairs Research Centers.

Erickson, Pat, Thomas Drabek, William Key, and Juanita Crowe, 1976. Families in Disaster. Mass Emergencies 1:206-213.

Fritz, Charles, 1957. Disasters Compared in Six American Communities. Human Organization 16(Summer):6-9.

Fritz, Charles E., 1961. Disasters. In R. Merton and R. Nisbet (eds.), Contemporary Social Problems. New York: Harcourt, Brace and World.

Fritz, Charles E., 1968. Disasters. In International Encyclopedia of the Social Sciences. New York: MacMillan and the Free Press.

Fritz, Charles and Marks, Eli, 1954. The NORC Studies of Human Behavior in Disaster. Journal of Social Issues 10(Number 3):26-41.

Goldstein, Arnold, 1960. Reactions to Disaster. Psychiatric Communications 3(April):26-41.

Houts, Peter and Goldhaber, Marilyn, 1981. Psychological and Social Effects on the Population Surrounding Three Mile Island After the Nuclear Accident on March 28, 1979, in S. Majumdar (ed.), Energy, Environment and the Economy. Pennsylvania Academy of Sciences.

Hudgens, Richard, 1974. Personal Catastrophe and Depression. In B. Dohrenwend and B. Dohrenwend (eds.), Stressful Life Events. New York: Wiley.

Kardiner, Abram, 1959. Traumatic Neuroses of War. In S. Arienti (ed.), American Handbook of Psychiatry. New York: Basic.

Kreps, Gary, 1979. A framework for comparing nuclear and nonnuclear disasters in terms of key defining properties of disaster events and generic functions of disaster response. Williamsburg, Virginia: Department of Sociology, College of William and Mary.

Lifton, Robert and Eric Olson, 1976. The Human Meaning of Total Disaster. Psychiatry 39:1-18.

Lindemann, Erich, 1944. Symptomatology and Management of Acute Grief. American Journal of Psychiatry 101:141-148.

Menninger, W. C., 1952. Psychological Reactions in an Emergency. American Journal of Psychiatry 109:128-130.

Mileti, Dennis, Thomas Drabek and Eugene Haas, 1975. Human Systems in Extreme Environments. Boulder, Colorado: University of Colorado, Institute for Behavoral Science.

Mileti, Dennis, Hartsough, Don and Madson, Pam, 1981. Unobtrusive Indicators of Stress at Three Mile Island. Fort Collins: Department of Sociology, Colorado State University.

Moore, Harry E., 1958a. Some Emotional Concommitants of Disaster. Mental Hygiene 42:45-50.

Moore, Harry E., 1958b. Tornadoes Over Texas. Austin: University of Texas Press.

Moore, Harry E., Frederick Bates, Marvin Layman and Vernon Parenton, 1963. Before the Wind: A Study of Response to Hurricane Carla. Washington, D.C.: National Academy of Sciences, National Research Council.

Moore, Harry E. and H. J. Friedsam, 1959. Reported Emotional Stress Following a Disaster. Social Forces 38:135-139.

Perry, Ronald, 1979. Detecting Psychopathological Reactions to Natural Disaster. Social Behavior and Personality 7(Number 2):173-177.

Perry, Ronald W., Greene, Marjorie, and Lindell, Michael, 1980. Human Response to Volcanic Eruptions: Mt. St. Helens, May 18, 1980. Seattle, Washington: Battelle Human Affairs Research Centers.

Perry, Ronald and Michael Lindell, 1978. The Psychological Consequences of Natural Disaster. Mass Emergencies 3(Number 2):105-115.

Quarantelli, E. L., 1960. Images of Withdrawal Behavior in Disasters. Social Problems, 9(Number 1):68-79.

Quarantelli, E. L., 1980. Evacuation Behavior and Problems. Columbus, Ohio: Ohio State University Disaster Research Center.

Quarantelli, Enrico, and Dynes, Russell, 1970. Property Norms and Looting: Their Patterns in Community Crises. Phylon, 31(Summer):168-182.

Quarantelli, Enrico, and Dynes, Russell, 1972. When Disaster Strikes. Psychology Today, 5(February):67-70.

Quarantelli, Enrico, and Dynes, Russell, 1977. Response to Social Crisis and Disaster. Annual Review of Sociology, 3:23-49.

Sterling, Joyce, Thomas Drabek and William Key, 1977. The Long-Term Impact of Disaster on the Health Self-Perceptions of Victims. Paper read at meetings of American Sociological Association, Chicago, Illinois.

Taylor, Verta, 1977. Good News About Disasters. Psychology Today 11(October):93-96.

Tyhurst, J. S., 1957a. Psychological and Social Aspects of Civilian Disaster. Canadian Medical Association Journal 76:385-393.

Tyhurst, J. S., 1957b. The Role of Transition States--Including Disasters--in Mental Illness, in National Research Council, eds., Symposium on Preventive and Social Psychiatry, pp.149-172. Washington, D.C.: Government Printing Office.

Wallace, Anthony, 1956. Tornado in Worcester. Washington, D.C.: National Academy of Sciences.

Wallace, Anthony, 1957. Mazeway Disintegration, Human Organization 16(Summer):23-27.

APPENDIX A

U.S. COURT OF APPEALS JUDGMENT

United States Court of Appeals

FOR THE DISTRICT OF COLUMBIA CIRCUIT

No. 81-1131

September Term, 1981

PEOPLE AGAINST NUCLEAR ENERGY, Petitioner

v.

UNITED STATES NUCLEAR REGULATORY COMMISSION and UNITED STATES OF AMERICA, Respondents

METROPOLITAN EDISON COMPANY, et al. (PUBLIC UTILITIES), Intervenors

United States Court of Appeals
for the District of Columbia Circuit

FILED JAN 7 1982

GEORGE A. FISHER
CLERK

Petition for Review of an Order of the United States Nuclear Regulatory Commission.

Before: WRIGHT, Circuit Judge, McGOWAN, Senior Circuit Judge, and WILKEY, Circuit Judge.

JUDGMENT

This cause came on to be heard on a petition for review of an order of the United States Nuclear Regulatory Commission and was briefed and argued by counsel.

On consideration thereof, it is ORDERED and ADJUDGED by this court that the order of the Nuclear Regulatory Commission under review in this cause is hereby vacated.

It is FURTHER ORDERED and ADJUDGED by this court that the Commission shall prepare an environmental assessment regarding the effects of the proposed restart of the nuclear facility at Three Mile Island Unit One (TMI-1) on the psychological health of neighboring residents and on the well-being of the surrounding communities. The Commission shall then determine, on the basis of this environmental assessment, whether the National Environmental Policy Act requires preparation of a full environmental impact statement.

It is FURTHER ORDERED and ADJUDGED by this court that, until the Commission has complied with the requirements of the National Environmental Policy Act as described in the preceding paragraph, it shall not make a decision to restart TMI-1.

It is FURTHER ORDERED and ADJUDGED by this court that the Commission shall prepare a statement of the reasons for its determination that psychological health is not cognizable under the Atomic Energy Act.

Opinions to follow.

Per Curiam

For the Court

George A. Fisher
Clerk

Circuit Judge WILKEY dissents. Whether designedly so or not, this order will bar the resumption of furnishing nuclear power from TMI-1, at which there has never been an accident, until such time as the Nuclear Regulatory Commission satisfies this court first by an "environmental assessment," and then, most likely, later by a required "full environmental impact statement," as to its consideration of certain new environmental factors. This delay is imposed because of the asserted impact "on the psycho-

logical health of neighboring residents," an "impact" which has never before been considered as covered by the National Environmental Policy Act.

This is yet another example of a court inventing new procedural requirements for an administrative agency in a manner which has enormous substantive consequences. See Vermont Yankee Nuclear Power Corp. v. NRDC, 435 U.S. 519 (1978). The court is concerned that "the well-being of the surrounding communities" be assessed, yet while this is taking place, for the communities near TMI-1 it will be a colder winter than predicted.

APPENDIX B

LIST OF ATTENDEES

TABLE B-1

EXPERT PARTICIPANTS

Andrew Baum, Ph.D.
Evelyn Bromet, Ph.D.
Robert Dupont, M.D.
Kai Erikson, Ph.D.
Peter Houts, Ph.D.
Stanislav Kasl, Ph.D.
Ronald Perry, Ph.D.
Captain Richard Rahe, M.D.
Jon Rolfe, Ph.D.
Paul Slovic, Ph.D.
George Warheit, Ph.D.

TABLE B-2

EXPERT OBSERVERS

Victor Fongemie, Ph.D.
Don Hartsough, Ph.D.
Robert Holt, Ph.D.
Dennis Mileti, Ph.D.
Henry Vyner, M.D.

TABLE B-3

ATTENDEES ON 4 FEBRUARY 1982

Elaine Baer
Lake Barrett
Andrew Baum
Deborah Bauser
Tom Brennan
William Clements
Dan Collins
Peter Crane
Jeanne Crumley
Donald Cleary
Enrico Conti
Harold Denton
Robert Dupont
Kai Erikson
Art Freedman
Victor Fongemie
Willard Fraize
Susan Frant
Sue Gagner
Judy Gordon
Vicki Harding
Don Hartsough
Robert Holt
Peter Houts
James Hurst
William Jordan
Channing Johnson
Stanislav Kasl
Kfiki Kehoe
Glenn Kinney
Rodney Lay
Jessica Laverty
Oliver Lynch
Al Manik
John Menke
Dennis Mileti
Daniel Muller
Raymond Olney
David Osterhout
Mike Parsont
Diane Pask
Ronald Perry
Gail Phelps
Richard Rahe
Ann Ramey-Smith
Pat Rathbun
William Regan
Jon Rolfe
Yale Schiffman
Martin Scholl
Paul Slovic
B. J. Snyder
Ted Sullivan
Joan Tahami
Gordon Trowbridge
Richard Vollmer
Henry Vyner
Pamela Walker
George Warheit
A. H. Wilcox
Isabella Wood
Dorothy Zinberg
Vicki Ziegenhagen

TABLE B-4

ATTENDEES ON 5 FEBRUARY 1982

Elaine Baer
Lake Barrett
Andrew Baum
Deborah Bauser
Evelyn Bromet
Donald Cleary
Enrico Conti
Don Collins
Laurie Davidson
Robert Dupont
Kai Erikson
Victor Fongemie
Ray Fleming
Art Freedman
Justin Frat
Willard Fraize
J. Gray
Judy Gordon
Don Hartsough
Peter Houts
Channing Johnson
Stanislav Kasl
Glenn Kinney
Rodney Lay
Oliver Lynch
John Menke
John Montgomery
Dennis Mileti
Lois Miller
Daniel Muller
Diane Pask
Ronald Perry
Gail Phelps
David Osterhout
Richard Rahe
Ann Ramey-Smith
Patricia Rathbun
William Regan
Jon Rolfe
Miller Spangler
Paul Slovic
March Schaeffer
Yale Schiffman
Ted Sullivan
B. Snyder
Joe Scinto
Joan Tahami
Gerry Tomlin
Gordon Trowbridge
Henry Vyner
Richard Vollmer
Pamela Walker
George Warheit
Vicki Ziegenhagen

APPENDIX C

WORKSHOP AGENDA

Workshop on
Psychological Stress

Agenda

Thursday, 4 February 1982

9:00 - 9:30	Opening Remarks - NRC - MITRE
9:30 - 10:30	Psychological Effects of Nuclear Power - nature and causes of stress associated with nuclear power - distinction from stress associated with other causes - observed stress responses associated with nuclear power
10:30 - 10:45	Break
10:45 - 12:00	Studies of Psychological Stress in the Vicinity of TMI - objectives - sample - methods - findings - conclusions
12:00 - 1:00	Lunch

1:00 - 2:45 Concepts, Causes and Consequences of Stress Which May Be Applicable to TMI-1 Restart

- general definitions of stress which may be related to the TMI-1 restart
- specification and clarification of differences in terminology and concepts
- identification of stimulus conditions from non-TMI studies which may be applicable to the TMI-1 restart context. What studies?
- identification of consequences of stress from non-TMI situations which may be applicable to the TMI-1 restart context. What studies?
- moderating or intervening factors

2:45 - 3:00 Break

3:00 - 3:45 Evaluation of Methods Used in Identification and Measurement of Stress and Stress Responses

- techniques for measurement (surveys, interviews, medical records, etc.) of stressors, intervening variables and outcomes
- validity, reliability and relevance of methods used

3:45 - 4:30 Ability to Extrapolate from Existing Studies to TMI-1 Restart

- similarities/dissimilarities in stressor events, populations, etc.
- other confounding factors to be considered

4:30 - 5:00 Focus for Tomorrow's Session

Friday, 5 February 1982

9:00 - 10:30	Continue and Conclude Discussion of Issues Identified at Close of Thursday Session
10:30 - 10:45	Break
10:45 - 12:15	Technical Considerations for Predicting Psychological Stress Associated with a Restart of TMI-1
12:15 - 1:15	Lunch
1:15 - 2:00	Identification of Additional Near Term Efforts Needed to Fill Gaps in Existing Concepts and Studies - benefit gained in terms of increased confidence in predictions
2:00 - 3:00	Summation of Workshop in Terms of Objectives

APPENDIX D

BIBLIOGRAPHY

SELECTED BIBLIOGRAPHY

Andrews, Gavin et al. "Life Event Stress, Social Support, Coping Style, and Risk of Psychological Impairment." Journal of Nervous and Mental Disease, 166(5), (May 1978) 307-316.

Barton, Allen. Communities in Disaster. New York: Basic Books.

Bates, Fred et al. The Social and Psychological Consequences of Disaster. Washington, D.C.: National Academy of Sciences - National Research Council, 1963.

Baum, Andrew et al. Chronic and Acute Stress Associated with Three Mile Island Accident and Decontamination, Preliminary Findings of a Longitudinal Study. Draft report submitted to U.S. Nuclear Regulatory Commission July 1981.

Baum, Andrew et al. Psychological Stress for Alternatives of Decontamination of Three Mile Island-2 Reactor Building Atmosphere. USNRC Report, NUREG/CR-1584, Washington, D.C.: 1980.

Baum, Andrew, and Gatchel, R. J. "Cognitive Determinants of Response to Uncontrollable Events: Development of Reactance and Learned Helplessness." Journal of Personality and Social Psychology, 40, (1981) 1078-1089.

Bennett, Timothy F. Final Report: Millirems, Mind Sets, Memoranda, and Meanderings. Department of Public Welfare, Office of Mental Health, State of Pennsylvania, June 1980.

Bromet, E. and Dunn, L. O. "Mental Health of Mothers Nine Months After the Three Mile Island Accident. Urban and Social Change Review, 14, (1981) 12-14.

Bromet, E. et al. Preliminary Report on the Mental Health of the Three Mile Island Residents. Prepared through support of NIMH Contract #278-79-0048 (SM), Department of Health and Human Services, National Institute of Mental Health, Disaster Assistance and Emergency Mental Health Section, May 1980.

Bromet, E.; Schulberg, H. C.; and Dunn, L. O. "Reactions of Psychiatric Patients to the Three Mile Island Nuclear Accident." Archives of General Psychiatry, in press.

Bromet, E. et al. Three Mile Island: Mental Health Findings. Prepared through support of NIMH Contract #278-79-0048 (SM), Department of Health and Human Services, National Institute of Mental Health, Disaster Assistance and Emergency Mental Health Section, October 1980.

Chisholm, R.F. and Kasl, S. V. "The Effects of Work Site, Supervisory Status, and Job Function on Nuclear Workers' Responses to the TMI Accident." Journal of Occupational Behavior, in press.

Chisholm, R.F. et al. "Behavioral and Mental Health Effects of the TMI Accident on Nuclear Workers: A Preliminary Report." Annals of the New York Academy of Sciences, 365 (1981) 134-145.

DeFleur, Melvin L. and Westie, Frank. "Verbal Attitudes and Overt Acts," American Sociological Review, 23, (1958) 667-673.

Dohrenwend, B. P. et al. "Report of the Task Group on Behavioral Effects, "Staff Reports to the President's Commission on the Accident at the Three Mile Island. Washington, D.C.: U. S. Government Printing Office, (1979) 257-308.

Dohrenwend, Bruce P. et al. "Nonspecific Psychological Distress and Other Dimensions of Psychopathology" Archives of General Psychiatry, 37 (11) (Nov. 1980) 1229-1236.

Dupont, R. L. "Fifty Million Frenchmen Have Few Nuclear Fears," Electric Perspectives. Edison Electric Institute, Summer 1981.

_____. "Nuclear Phobia: Phobic Thinking About Nuclear Power," Nuclear Power in American Thought, Decisionmakers, 8, Edison Electric Institute, (1981) 23-41.

_____. "Phobic Fear as a Nuclear Health Hazard," The Washington Star, July 20, 1980.

Eisdorphor, Karl and Elliott, Glen R. Research on Stress and Human Health, Report of a Study by Committee of the Institute of Medicine, National Academy of Sciences, IOM #81-05, Washington, D.C.: 1981.

Erikson, Kai. Everything in Its Path: Destruction of Community in the Buffalo Creek Flood. New York: Simon and Schuster, 1976.

_____. "Loss of Communality on Buffalo Creek,"American Journal of Psychiatry, 133 (1976) 302-306.

Fischhoff, B. S. et al. Approaches to Acceptable Risk: A Critical Guide. NUREG/CR-1614. Nuclear Regulatory Commission, Washington, D.C. 1980.

_____. "How Safe is Safe Enough? A psychometric study of attitudes towards technological risks and benefits." Policy Sciences 9, (1978), 127-152.

Flynn, C. Three Mile Island Telephone Survey, Preliminary Report on Procedures and Findings, U.S. Nuclear Regulatory Commission, Washington, D.C., 1979.

Frank, Jerome D. "Common Features of Psychotherapies and Their Patients" Psychotherapy and Psychosomatics, 24 (1974) (4-6) 368-371.

Gamble, H. and Downing, R. Effects of the Accident at Three Mile Island on Residential Property Values and Sales, U. S. Nuclear Regulatory Commission, Washington, D.C., 1979.

Goldhaber, M.; Houts, P.; and DiSabella, R. Mobility of the Population Within 5 Miles of Three Mile Island During the Period from August 1979 through July 1980. Report submitted to the TMI Advisory Panel on Health Research Studies of the Pennsylvania Department of Health, 1981.

Governor's Office of Policy Planning. The Socio-Economic Impacts of the Three Mile Island Accident: Final Report, Harrisburg, Pa., 1980.

Harding, John and Hogrefe, Russell. "Attitudes of White Department Store Employees Towards Negro Co-Workers," Social Issues, 8, (1952), 18-28.

Horowitz, Mardi J. and Solomon, George F. "A Prediction of Delayed Stress Response Syndrome in Vietnam Veterans," Journal of Social Issues, 4 (1975) 31 67-80.

Houts, Peter and Goldhaber, Marilyn. "Psychological and Social Effects on the Population Surrounding TMI After the Nuclear Accident on March 28, 1979," Energy, Environment and the Economy, Chapter 14, S. Majumdar, editor. Pennsylvania Academy of Sciences, 1981.

Houts, Peter et al. Health-Related Behavioral Impact of the Three Mile Island Nuclear Incident Parts I and II. Report submitted to the TMI Advisory Panel on Health Research Studies of the Pennsylvania Department of Health, 1980.

_____. Health-Related Behavioral Impact of the Three Mile Island Nuclear Incident Part III. Report submitted to the TMI Advisory Panel on Health Research Studies of the Pennsylvania Department of Health, 1981.

Houts, P.; DiSabella, R.; and Goldhaber, M. "Extent and Duration of Psychological Distress of Persons in the Vicinity of Three Mile Island," Proceedings of the Pennsylvania Academy of Science, 54, (1980) 22-28.

Hu, T. et al. Health-Related Economic Costs of the Three Mile Island Accident. Report submitted to the TMI Advisory Panel on Health Research Studies of the Pennsylvania Department of Health, 1981.

Hudgens, Richard. "Personal Catastrophe and Depression," Stressful Life Events, Dohrenwend, B. and Dohrenwend, B. (Eds.) New York: Wiley, 1974.

Janis, Irving and Mann, Leon. "Emergency Decision Making." Journal of Human Stress, 3, (1977) 35-45.

Kasl, S. V.; Chisholm, R. F.; and Eskenazi, B. "The Impact of the Accident at the Three Mile Island on the Behavior and Well-Being of Nuclear Workers: Part I. Perceptions and Evaluations, Behavioral Responses, and Work-Related Attitudes and Feelings," American Journal of Public Health, 71, (1981) 472-483.

_____ "The Impact of the Accident at the Three Mile Island on the Behavior and Well-Being of Nuclear Workers: Part II. Job Tension, Psychophysiological Symptoms, and Indices of Distress." American Journal of Public Health, 71, (1981) 484-495.

Karotkin, Kenneth M. "A Comparison of Vietnam Veterans, Vietnam era Veterans, and Non-veterans in Terms of Political Alienation, Purpose in Life, and Life Stress", Dissertation Abstracts International, 36 (12-A) (June 1976), 7952-7953.

LaPiere, R. T. "Attitudes vs. Actions," Social Forces, 13, 1934, 230-237.

Lifton, Robert and Olson, Eric. "The Human Meaning of Total Disaster," Psychiatry 39:1 - 18.

Linn, Lawrence. "Verbal Attitudes and Overt Behavior: A Study of Racial Discrimination." Social Forces 43, (1965) 353-364.

Logue, James N. and Hansen, Holger. "A Case-Control Study of Hypertensive Women in a Post Disaster Community: Wyoming Valley, Pa.," Journal of Human Stress, 6 (2) (1980) 28-34.

Melick, Mary E. "Life Change and Illness: Illness Behavior of Males in the Recovery Period of a Natural Disaster", Journal of Health and Social Behavior, 19(3) (Sept 1978) 335-342.

_____. "Social, Psychological and Medical Aspects of Stress Related Illnesses in the Recovery Period of a Natural Disaster," Dissertation Abstracts International, 37 (2-A), (Aug. 1976) 1239-1240.

Mileti, Dennis S.; Hartsough, Donald; and Madsen, Patti. The Three Mile Island Incident: A Study of Behavioral Indicators of Human Stress. A report prepared for Shaw, Pittman, Potts and Trowbridge, Legal Counsel to General Public Utilities and Metropolitan Edison, final report forthcoming.

Morell, Jonathan A. and Spivak, George. Review of Studies on the Psychological and Behavioral Impact of the TMI Nuclear Accident, with Specific Implications for Research and Planning, (unpublished). Department of Mental Health Sciences, Hahnemann Medical College, Philadelphia, Pa., Oct. 1980.

Perry, Ronald. "Detecting Psychopathological Reactions to Disaster," Social Behavior and Personality, 7, No. 2 (1979) 173-177.

Perry, Ronald; Lindell, Michael; and Green, Marjorie. "Flood Warning: How People React After the Warning," The Hazard Monthly 1, 11 (1981) 1-6.

_____. Human Response to Volcanic Eruption: The case of Mt. St. Helens, New York: Irvington Publishers, 1982.

Perry, Ronald and Lindell, Michael. "The Psychological Consequences of Natural Disasters," Mass Emergencies, 3, No. 4 (1978) 194-204.

Perry, Ronald; Lindell, Michael; and Greene Marjorie. "Threat Perception and Public Response to Volcano Hazard." Journal of Social Psychology, in press.

Quarantelli, Enrico. "Images of Withdrawal Behavior in Disasters," Social Problems, 9, No. 1 (1960) 68-79.

Quarantelli, Enrico and Dynes, Russell. "Response to Social Crisis and Disaster," Annual Review of Sociology, 3, (1977) 23-49.

_____. "When Disaster Strikes," Psychology Today, 4 (1972) 67-70.

Rahe, R. H. "Life Change Events and Mental Illness: An Overview" Journal of Human Stress, 5(3) (Sept. 1979) 2-10.

_____. "The Pathway Between Subjects Recent Life Changes and Their Near-Future Illness Reports: Representative Results and Methodologies Issues" In B.S. Dohrenwend and B. R. Dohrenwend (eds.) Stressful Life Event: Their Nature and Effects. New York: John Wiley and Sons, Inc., 73-86, 1974.

Richlin, M.; Shale, J. H.; and Rahe, R. H. "Five Year Medical Follow-up of Navy POWs Repatriated from Vietnam: Preliminary Results," U.S. Navy Medicine, 71 (August 1980) 19-26.

Rolf, J. "Special Issue on Stress, Social Support and Schizophrenia" Schizophrenia Bulletin, Vol. 7, No. 1.

Segal, J. Long-Term Psychological and Physical Effects of the POW Experience: A Review of the Literature, Naval Health Research Center for POW Studies, San Diego, California, U.S. Naval Health Research Center Report, 74-2, (Jan.1974) 29.

Scranton, W. Report to the Governor's Commission on Three Mile Island, Harrisburg, Pa., 1980.

Shearer, D. Three Mile Island Nuclear Accident Community Impact Study on Real Estate. Harrisburg, Pa.: Greater Harrisburg Board of Realtors, 1980.

Slovic, P.; Kunreuther, H.; and White, G. F. "Decision Processes, Rationality, and Adjustment to Natural Hazards." In G. F. White (Ed.), Natural Hazards, Local, National and Global. New York: Oxford University Press, 1974, 187-205.

Slovic, P.; Lichtenstein, S.; and Fischhoff, B. "Images of Disaster: Perception and Acceptance of Risks from Nuclear Power." In G. Goodman and W. Rowe (Eds.), Energy Risk Management. London: Academic Press, 1979, 223-245.

Slovic, P.; Fischhoff, B.; and Lichtenstein, S. "Perceived Risk and Quantitative Safety Goals for Nuclear Power." Transactions of the American Nuclear Society, 35, (1980) 400-401.

_____. "Rating the Risks." Environment, 21 (3), (1977) 14-20, 36-39.

_____. "Perception and Acceptability of Risk from Energy Systems, "In A. Baum & J. E. Singer (Eds.) Advances in Environmental Psychology, 3, Hillsdale, N. J.; Erlbaum, 1981.

_____. "Psychological Aspects of Risk Perception." In D. Sills, C. P. Wolf, and V. Shelanski (Eds.), The Accident at Three Mile Island: The Human Dimensions. Boulder, Colorado: Westview.

Takuma, Taketoshi. "Human Behavior in the Event of Earthquakes" In E. L. Quarantelli (Ed.) Disasters: Theory and Research, Beverly Hills, California: Sage, 1978, 159-172.

Warheit, G. J., with B. P. Dohrenwend et al. Stress in the Community: A Report to the President's Commission of the Accident at Three Mile Island. Annals of the New York Academy of Sciences. 365 (1981) 159-174.

Wilkes, J. M. et al. Formation of Attitudes about Nuclear Power. Paper presented at the Third Annual Meeting of the Society for the Social Study of Science, Bloomington, Indiana 1978.

NRC FORM 335 (7-77) U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

1. REPORT NUMBER (Assigned by DDC)
NUREG/CP-0026
MTR-82W26

4. TITLE AND SUBTITLE (Add Volume No., if appropriate)

Workshop on Psychological Stress Associated With the Proposed Restart of Three Mile Island, Unit 1

2. (Leave blank)

3. RECIPIENT'S ACCESSION NO.

7. AUTHOR(S)

P. Walker, W.E. Fraize, J.J. Gordon, R.C. Johnson

5. DATE REPORT COMPLETED
MONTH: March YEAR: 1982

9. PERFORMING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)

Energy and Resources Division
The MITRE Corporation
McLean, VA 22102

DATE REPORT ISSUED
MONTH: April YEAR: 1982

6. (Leave blank)

8. (Leave blank)

12. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)

U.S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Division of Engineering
Washington, DC 20555

10. PROJECT/TASK/WORK UNIT NO.

11. CONTRACT NO.
NRC FIN B8048
NRC-03-82-113

13. TYPE OF REPORT

Technical Report

PERIOD COVERED (Inclusive dates)

January 1982 - March 1982

15. SUPPLEMENTARY NOTES

14. (Leave blank)

16. ABSTRACT (200 words or less)

On 4 and 5 February 1982, eleven experts in the field of psychological stress and related fields met for a two-day Workshop at The MITRE Corporation, McLean, Virginia. The general purpose of the Workshop, sponsored by the Nuclear Regulatory Commission, was to assess the state-of-knowledge relevant to assessing psychological stress which may be associated with the restart of the nuclear power reactor Unit 1 at the Three Mile Island site of the Metropolitan Edison Company (TMI-1). Of particular interest was the extent to which existing concepts and studies might be used to extrapolate or infer the range of stress responses likely to result from the proposed restart of TMI-1. This report summarizes the discussions of the Workshop participants.

17. KEY WORDS AND DOCUMENT ANALYSIS

17a. DESCRIPTORS

Psychological Stress
Three Mile Island

17b. IDENTIFIERS/OPEN-ENDED TERMS

18. AVAILABILITY STATEMENT

Unlimited

19. SECURITY CLASS (This report)
Unclassified

21. NO. OF PAGES

20. SECURITY CLASS (This page)
Unclassified

22. PRICE
$